Issued January 31, 1911.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS—MILTON WHITNEY, Chief.

SOIL SURVEY OF THE WOODLAND AREA, CALIFORNIA.

BY

C. W. MANN, J. F. WARNER, H. L. WESTOVER,
AND JAMES E. FERGUSON.

[Advance Sheets—Field Operations of the Bureau of Soils, 1909.]

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1911.

[PUBLIC RESOLUTION.—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided,* That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., June 22, 1910.

SIR: The accompanying report and soil map cover the survey of the Woodland area, California, one of the projects undertaken by the Bureau during the field season of 1909. Requests for this work were received from prominent citizens of the area, indorsed by the Hon. D. E. McKinlay, within whose Congressional district the area lies. I recommend the publication of this report as advance sheets of Field Operations of the Bureau of Soils, 1909, as provided by law.

Very respectfully,

MILTON WHITNEY,
Chief of Bureau

Hon. JAMES WILSON,
Secretary of Agriculture.

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SOIL SURVEY OF THE WOODLAND AREA, CALIFORNIA.

By C. W. MANN, J. F. WARNER, H. L. WESTOVER, and JAMES E. FERGUSON.

DESCRIPTION OF THE AREA.

The Woodland area is situated in the southwestern part of the Sacramento Valley. The northern boundary is limited by parallel 39° 10′ north latitude, where the area joins the Colusa area, of which a soil survey has been made by the Department. The southern boundary is formed by Putah Creek and, east of Davisville, by parallel 38° 30′ north latitude. On the east the area extends to the Sacramento River and on the west it terminates in an irregular line near the base of the foothills. Between Arbuckle and Winters the survey was carried from 3 to 6 miles beyond the territory covered by the topographic map issued by the United States Geological Survey. The length of the area from north to south is about 47 miles and its area 656,000 acres, or 1,025 square miles.

FIG. 1.—Sketch map showing location of the Woodland area, California.

The region embraces three prominent physiographic divisions traversing the area in a northwest-southeast direction. These are the low foothills and mountain slopes that form the western rim of the Sacramento Valley, the extensive plain of the valley floor, and,

to the east, the broad depression of the Yolo and Colusa basins, which terminate in a slightly elevated ridge along the Sacramento River.

A striking feature of the valley topography is the extensive area of lowland included in the Yolo and Colusa basins. The continuity of this natural trough or depression is interrupted in the vicinity of Knights Landing by a transverse ridge extending westward along the course of Cache Creek Slough, forming to the north the Colusa Basin and to the south the Yolo Basin. The lowest elevation is reached at from 1 to 6 miles west of the Sacramento River, resulting at this point in a poorly defined trough, through which a drainage channel discharges the waters accumulated during the rainy season into the Sacramento River at Knights Landing, or farther south in the Yolo Basin into Cache Slough. To the east the surface slope is toward the Sacramento River and on the west side the basins merge into the upland plain without distinct boundaries. The surface of the region is flat. Shallow sinks occur in which surface water remains until dispelled by evaporation. The native vegetation consists of a thick growth of tules, smartweed, mint, and other aquatic or semiaquatic plants, and along the Sacramento River, south of Eldorado Bend, of a tangled forest growth of willow, cottonwood, alder, and brush. No extensive areas of permanent swamp land occur in the lowlands. The flood waters of the Sacramento River and the various creeks and sloughs of the area are impounded during the rainy season, but with the subsidence of the streams are gradually dispelled, leaving the greater part of the area dry from July to October.

Wheat and barley have been planted in different parts of the region in years of light rainfall, but the growing of cultivated crops in the area subject to overflow is too hazardous to be often attempted, and the lands are at present utilized only as pasture during the summer months. Extensive reclamation works have been constructed near Washington and Grand Island, and some large tracts have been reclaimed and are devoted to the production of grain, tilled crops, and fruit.

Along the eastern rim of the lowlands the Sacramento River, by the deposition of sediment, has built up a slightly elevated ridge which marks the meandering course of the stream. A narrow belt of farming land occupies the more elevated area near the river, and is protected from overflow by a system of levees which are maintained at sufficient height to retain the river at flood stage.

The surface of the valley floor, west of the lowlands, resembles a slightly inclined plain. It has a rise of from 5 to 10 feet to the mile and terminates in the lower slopes of the foothills in the western part of the area. To the south and west of College City the rise is more abrupt, the general ascent increasing to about 50 feet to the mile.

Throughout the greater part of this region the plain presents a decidedly flat appearance. The surface is dissected by numerous sloughs and creeks and in some instances the larger streams, as Putah, Cache, Buckeye, and Cottonwood creeks, have cut deep channels in the thick alluvium of the plain. A typical feature of the valley streams is the tendency to create ridges along their course by the gradual deposition of sedimentary material. In this manner have been built up the elevated beds of Cortina and Cache creeks, and Corbiere, Sycamore, Willow, and other sloughs.

In the western part of the area a chain of low hills extends from a few miles southwest of Williams in a general southeasterly direction to Cache Creek, disappearing in a series of isolated mounds and ridges a few miles southwest of Woodland. Farther west the area reaches the abrupt slopes of the main foothills of the Coast Range Mountains.

The general direction of the drainage is northeast toward the Sacramento River. Northward from Cache Creek, Oak, Buckeye, Salt, and Cortina creeks form important streams during the rainy season. With a number of minor sloughs they discharge into the Colusa Basin. Cache and Putah creeks and Willow Slough drain the southern part of the area and flow into the Yolo Basin. The essential feature of the regional drainage is the obstruction presented by the Yolo and Colusa basins to the easterly flow of the upland streams and the accumulation of the flood waters in these reservoirs for a period of several months of the year. Cache Creek forms the outlet of Clear Lake, situated about 40 miles northwest of Capay in the Coast Range Mountains, and is the source of water supply for the system of irrigating canals operated by the Yolo County Consolidated Water Company.

Over a large part of the country districts the population is sparse. The early settlers were recruited largely from the Middle West and Middle Atlantic States. Their lands were secured by grants or by purchase from the United States Government. Large holdings were acquired along Cache and Putah creeks by the grants of extensive tracts made by the Mexican Government prior to the ceding of California to the United States in 1848. For many years the tendency has been toward the absorption of the smaller by the larger estates, which have been better adapted to the prevailing type of grain farming. The present population of the rural districts is made up largely of the descendants of the early settlers. In the more prosperous grain-farming sections of the area expensive farm dwellings and large commodious outbuildings are of common occurrence. In the more highly developed fruit-growing sections neat farmsteads and active community life are prevalent. The owners of the large estates occasionally live in the towns, and either supervise the farm work during

the period of sowing and harvesting the grain crops or rent to tenants. The foreigner, including Japanese, Chinese, Italian, and Hindoo, is employed to some extent as farm labor. The Italian is principally engaged in vegetable gardening and with the Chinese and Japanese grows the bulk of the vegetables for the local markets.

The census of 1900 gives the population of Yolo and Colusa counties as 13,618 and 7,365, respectively. During recent years the population has been increasing in the vicinity of Woodland, Winters, Grimes, Arbuckle, and at other places, as a result of the increase of small farms in these sections.

There occur in the area a number of important towns, which have modern improvements and well-organized schools and churches. Woodland, the county seat of Yolo County, has a population of about 3,500. It lies in the midst of a rich agricultural section, near the geographical center of the area surveyed in Yolo County, and is 87 miles by rail from San Francisco and 23 miles from Sacramento. Winters, in the extreme southwest part of the area, is a progressive town situated in the center of a well-organized and prosperous deciduous fruit district. Davis, Knights Landing, and Washington are other towns of good size in the southern part of the area. Grimes, in Colusa County, on the Sacramento River, is an active shipping point for the large grain production of the Grand Island and Mormon Basin district. Farther west are the towns of Williams, Arbuckle, and College City, affording markets and shipping points for grain and fruit products. The farm and farm school connected with the Agricultural College of the University of California are located at Davis.

In pleasing contrast to roads in the rougher parts of the country are the main country highways, which are broad and well graded and kept in excellent condition for travel during the greater part of the year. A very durable road material is found in the area in the gravel beds of streams and clayey gravels of the hills, and this is largely used as ballast on the roads. In the areas of adobe soils the roads become very heavy and in places almost impassable during the rainy season, but rapidly form a smooth, compact surface in dry weather.

The San Francisco-Tehama branch of the Southern Pacific system passes through the area from north to south, and connects with points in the upper part of the valley and with northern coast cities. At Davis it joins the main line between Sacramento and San Francisco. A branch line connects Woodland and Knights Landing with points on the east side of the valley. In addition, railroad connection is afforded the southwestern part of the area by a spur line which leaves the main road at Elmira and connects the towns of Winters, Madison, and Capay. This road forms the outlet to the Capay Valley, which extends some distance beyond the present survey.

The local markets consume most of the dairy and poultry products of the area. The outlet for the grain, fruit, wool, and beef products is by rail and water to Sacramento, San Francisco, and other cities and to the eastern or foreign markets. The facilities for the marketing of these products are, as a rule, adequate and are capable of being greatly extended with an increase in the export of fruit, dairy products, vegetables, and other produce. Having a water frontage for its entire length, the area ultimately should be open more fully to direct water transportation via the Sacramento River to many parts of the State and to foreign markets.

CLIMATE.

The climate of the Woodland area, in common with that of other parts of the Central Valley of California, is characterized by a dry summer season, during which there is almost entire absence of rain, and a winter or rainy season. The two seasons are of somewhat indefinite extent. In some years the rains begin in the fall as early as September 15 and end as late as June 1. At other times no rains occur until the middle of November and none after the middle of March. The dry season ordinarily extends from about May 15 to October 15. The rainfall is generally fairly well distributed throughout the winter months, though occasionally the greater part of the precipitation occurs within a period of sixty days. Severe thunderstorms, hail, and snow are rarely experienced in this region.

The normal mean temperature at Williams, in the northern part of the area, for January and February is 48°, for July and August it is 82.2°. At Sacramento, near the southwestern part of the area, the normal mean temperature for January and February is 49.3° and for July and August 71.7°. It will be apparent from these figures that there is but slight variation in the winter temperature between the northern and southern parts of the area and that the mean summer temperature increases northward.

During the summer months there is usually entire freedom from fogs. There are a large number of clear, warm days and cool nights. The high temperatures that often prevail during July, August, and September usually occur as short periods of hot days, followed by cool, delightful weather. Owing to the low relative humidity, the heat, even when excessive, is felt less than would be supposed from the records of absolute temperatures. The wind movement is usually moderate. The south wind during the summer months is accompanied by a lowering of the temperature, which greatly modifies the climate.

A feature of the spring and summer climate is the hot north wind or "norther," which occurs at intervals of one to three weeks or more

and extends over a period of one to three days. The rise in temperature which accompanies the periods of north winds renders them very desiccating and disagreeable and occasionally injurious to grain crops, tree fruits, and grapes. These are frequently followed by south breezes and cooler weather.

During the winter months the rains occur as light showers continuing from one to several days. There are periods of fair weather during the rainy season when the temperature rises and conditions are favorable for the plowing and seeding of grain crops, the greater part of which is done at this season. Heavy fogs are frequently experienced in the winter months. In extreme cases these are continuous for days at a time.

The first light frosts occur about October 12, and the last in the spring about May 10. The average date of the first killing frost in the fall is November 15, and the last in the spring, March 20.

In contrast to the coast climate at San Francisco Bay is the higher degree of summer heat and a lower average winter temperature of the interior. The mean annual temperature of Sacramento is 4° F. higher than that of San Francisco. The greatest difference during any month occurs in July when the mean average difference in temperature is 15° F. The average rainfall decreases inland, being 23 inches at San Francisco and 19.21 at Sacramento. The interior points are relatively free from summer fogs, have a greater number of clear days, and lower humidity during the summer months than the coast towns.

The climatic conditions in general are favorable to the production of grain and other crops, the early ripening and coloring of fruits, and the open-air curing of dried fruits. The dry air of the summer and late spring makes the region comparatively free from certain insect and fungus troubles affecting the fruit and trees in regions of greater humidity. Damage to fruit and foliage is occasioned in certain sections by "sun-burning" during hot weather, though the loss from this source is usually slight. Near the foothills and minor valleys at Winters, Capay, and west of Williams fruit ripens somewhat earlier than in the lower parts of the valley, placing these foothill locations among the early fruit sections of the State. A fairly distinct climatic zone exists in close proximity to the Sacramento River. Increased humidity, occasional fogs at night in the summer, and greater freedom from hot winds are the principal climatic differences between the plain and the river sections.

On the following page is given a table showing the normal mean annual temperature and precipitation of places occurring within or adjacent to the area, compiled from the records of the United States Weather Bureau:

Normal monthly and annual temperature and precipitation.

Month.	Davisville.		Dunnigan.		Knights Landing.		Woodland.		Vacaville.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	In.	°F.	In.	°F.	In.	°F.	In.	°F.	In.
January	47.6	3.51	46.3	4.36	46.8	3.41	46.2	3.77	46.4	5.87
February	51.6	2.38	49.2	2.35	50.3	2.47	49.9	2.39	51.2	3.44
March	56.2	2.20	55.0	2.40	54.8	2.25	54.5	2.20	54.3	3.79
April	60.8	1.39	62.4	1.54	59.2	1.74	59.9	1.51	59.0	2.44
May	67.9	.68	70.3	.94	66.6	.94	66.9	.76	65.1	1.44
June	74.8	.18	77.9	.20	72.3	.24	74.3	.26	71.9	.17
July	77.9	.02	81.8	.00	77.4	.00	78.7	.01	76.0	.00
August	74.1	.01	79.7	.02	76.6	.00	76.2	.01	75.2	.04
September	72.0	.21	74.6	.36	70.9	.32	71.1	.24	71.2	.30
October	64.9	.87	69.3	1.03	62.7	1.01	63.7	1.09	64.4	1.44
November	55.7	1.76	55.0	2.07	54.1	2.18	54.8	2.29	55.7	3.08
December	48.8	3.33	47.3	3.83	48.4	3.66	48.4	3.20	47.6	5.88
Year	62.7	16.54	64.1	19.10	61.7	18.22	62.1	17.73	61.5	27.89

The following table gives climatological data for Sacramento, Cal., from July 1, 1877, to December 31, 1900:

Number of clear, partly cloudy, cloudy, rainy, and foggy days, and total number of thunderstorms from July 1, 1877, to December 31, 1900.

Month.	Clear.	Partly cloudy.	Cloudy.	Rainy days 0.01 or more.	Foggy days.	Total number thunderstorms.
January	200	195	247	217	131	2
February	275	219	156	176	43	3
March	311	218	184	116	14	9
April	348	228	114	147	3	10
May	441	182	90	88	0	16
June	548	107	35	26	1	6
July	698	40	6	1	0	3
August	674	57	13	3	0	15
September	599	88	33	35	1	12
October	514	186	64	80	15	3
November	419	160	141	134	53	3
December	253	215	276	223	153	2
Total	5,340	1,895	1,359	1,246	414	74
Annual average	229	80	56	53	18	3

AGRICULTURE.

The earliest settlement of importance in the Woodland area was upon the Gordon land grant, which was secured from the Mexican Government by William Gordon in 1841. This grant comprises 2 square leagues of land along Cache Creek, and in the spring of 1842 a

settlement was established a few miles west of the present site of Woodland. During the next few years other extensive grants were secured on Putah Creek, at Knights Landing, and Sycamore. It was after the discovery of gold in California in 1849, however, which was followed by a rapid immigration to the Sacramento Valley, that the active settlement of the region began.

The first crops were grown along the Sacramento River and consisted of corn, sweet and Irish potatoes, melons, and other vegetables, and hay. The luxuriant growth of wild grasses on the plains of Yolo and Colusa counties and the mild climate of the region were favorable to stock raising, and this industry grew to great proportions between 1850 and 1862. The common cattle were of poor quality, being the Mexican longhorn type. Prior to 1860, however, a considerable number of American-bred cattle were brought across the plains from the East. Stock raising continued to be the principal occupation of the settlers until the years 1862 and 1863. During these two seasons a prolonged drought occurred, which caused a scarcity of pasturage on the plains, and as a consequence a large number of stock perished. This resulted in great loss to the cattlemen and brought about a change in agricultural practices and hastened the development of new industries.

The introduction of methods of dry farming in the early sixties led to the extension of grain growing from the river-bottom lands to the dry soils of the plains and brought into cultivation large areas which had been previously regarded as unsuited to farming. By 1870 the production of wheat and barley had become the dominant industry in this part of the State. Within a comparatively few years many of the cattle ranges were converted into extensive grain ranches.

At the present time the principal agricultural products of the area consist of live stock, wheat, barley, alfalfa, sugar beets, and other field crops, deciduous fruits, and dairy products. By far the greater part of the area is exclusively devoted to the production of barley and wheat under the methods of dry farming. The general method employed in the production of these crops has changed but little during recent years. The decline in yield of the grain crops, which has resulted from the exhaustive system followed and the production of a single crop—wheat or barley—has been largely met by the use of highly improved machinery, making practicable the cultivation of extensive tracts. The land is prepared for the grain crops during the fall and winter. The gang plow with three to five shares, which is capable of covering from 6 to 12 acres in a day, is in general use. Plowing is usually shallow, ranging from 3 to 6 inches, and the surface is leveled and pulverized by a broad, sectional smoothing harrow. A rotary broadcast seeder is used in seeding the grain in place of the grain drill, as it covers several times the area that can be drilled. From 75 to 100 pounds of seed is sown to the acre. In the majority

of cases in the cultivation of the grain crops but little attention is paid to maintaining or increasing the crop yields. No system of crop rotation is practiced to any extent. Under dry farming the land is fallowed in alternate years and wheat or barley is grown continuously on the same land. While the value of crop rotations and the use of green manuring crops are generally recognized, these have not proved to be practicable under present conditions. As in other parts of the Sacramento Valley, the small-grain grower, as a result of declining yields, has in some cases been forced to abandon his property, which has been acquired by the larger land owners. Such lands, however, under irrigation can usually be made very productive to other crops, and when irrigation water can be had the depleted grain lands will undoubtedly give larger returns in general or specialized farming.

Land that is summer-fallowed is plowed in the spring at the close of the rainy season. It is replowed and seeded preferably early in the fall or soon after the first fall rains. In general, the yields of barley vary from less than 5 to 25 sacks to the acre, the average over most of the area being probably not over 10 sacks to the acre.

The harvest season extends from June 1 to the middle of July. The introduction of the combined harvester about 1890 led to the substitution of this machine for the header and thrasher. The modern harvester cuts a swath 15 to 30 feet wide and thrashes and sacks the grain from an area of 25 to 30 acres in one day. The crop is frequently cut by contract, the usual rate being $1.50 per acre, or about $40 a day. The sacked grain is stored in large warehouses, where it is sampled and bought by the grain buyers.

In 1896 the acreages devoted to wheat and barley in Yolo County were 160,000 and 16,000 acres, respectively, and in 1906 approximately 150,000 acres was in barley and 80,000 acres in wheat. It will be seen from these figures that the total area of grain crops increased by 54,000 acres during this decade and that this increase took place in the barley acreage. This is said to be due to the larger yields of the crop and the higher prices secured for this staple during recent years.

Barley is frequently cut green and cured as hay, and it is the principal hay crop on most of the ranches in the grain-growing districts. Alfalfa is grown to a considerable extent in connection with dairying in the southern part of the area and along the Sacramento River. A considerable amount of alfalfa hay is baled and sold in the local market or shipped to the near-by cities. This crop was grown near Woodland as early as 1856. Under irrigation it is one of the most profitable crops produced in the area, owing to the large demand for the baled hay and to its superiority as a pasture or hay crop upon the dairy or stock farms. Alfalfa produces from three to five crops a

year, the yields varying from 4 to 9 tons per acre. The first two cuttings are usually made before the crop is irrigated, and water is applied just before or immediately after cutting each succeeding crop. Alfalfa is planted at any time between the middle of March and the middle of April. When practicable, the crop should be started while there is sufficient moisture in the soil to produce a vigorous growth without the necessity of irrigating the surface. While the bulk of this crop is now produced near the existing irrigation canals, with the extension of irrigation to other parts of the area alfalfa will undoubtedly prove to be well adapted to a very large area of the sandy loam, loam, and clay loam types of the plain and the river sections.

Within recent years the growing of sugar beets has given promise of considerable success. Most of this crop has been produced, as yet, in the southern part of the area. Under efficient cultivation and on the more productive soils the yields vary from 6 to 15 tons to the acre, with an average of about 12 tons, the beets showing a sugar content of 13 to 20 per cent and an average purity of over 80 per cent. The crop is usually grown under contracts, which are made with the sugar factories at the beginning of each year. The prevailing price is $4 a ton for beets having 13 per cent sugar, with an increase of 25 cents a ton for each additional per cent above this standard. The average cost of producing an acre of beets is estimated at about $25.

The land for this crop is usually plowed deep in the fall, followed by shallower plowing and thorough cultivation in the spring. The crop is usually planted between the middle of March and the 1st of May. In general, the best results have been secured by early spring planting. The seed is drilled in rows about 16 inches apart. When the plants are well started, the rows are thinned by hand, the plants being left about 5 inches apart. The plants receive four or more cultivations during the season. Most of the crop has been grown without irrigation, though in some cases irrigation has been found largely to increase the yields. It is said, however, that the irrigated beet is sometimes of inferior quality. The furrow method of irrigation, the furrows being run so as to permit a continuous flow of water, has been found to be preferable to flooding in checks, which frequently causes an objectionable caking of the soil around the crown of the beets.

So far the most satisfactory crops have been secured on the soil types ranging in texture from the silt loams to sandy loams, though it is probable that sugar beets can be grown with success on most of the soils of the plains region and river bottoms, with the exception of the heavy, clay adobe types, where these soils are well drained and free from alkali. The clean culture required by this crop makes it espe-

cially fitted for use in a rotation with wheat or barley and clover, alfalfa, or some other leguminous crop.

Dairying is an industry which is increasing in importance in different parts of the area. At the present time the largest dairy farms are found in the vicinity of Woodland and Yolo and at different points on the Sacramento River, though in the aggregate a considerable amount of dairy stock is kept on the ranches in other parts of the area. Considering the excellent opportunities that exist for dairy farming in the area, comparatively little has been done as yet to develop this industry.

A large number of horses, mules, cattle, sheep, and hogs are raised. The herds of cattle and sheep frequently find pasture in the lowlands during the dry summer months and are transferred to the uplands or foothills in the fall. Upon the dairy farms the stock is of good quality, being mainly Holsteins, while purebred Shorthorn cattle and Shropshire sheep are raised for market near Woodland. About 800,000 pounds of wool, including mohair, was produced in Yolo and Colusa counties in 1906. Turkeys are sometimes kept and herded in large flocks in the grain fields, though, in general, there is a lack of interest in poultry raising, and good opportunities exist along this line, as poultry products command good prices throughout the year.

In the neighborhood of Broderick hops are an important crop. Upon the lighter soils along the Sacramento River and Cache and Putah creeks the production of early vegetables is a profitable business, which is carried on by Japanese, Chinese, and Italian gardeners.

Wine, raisin, and table grapes are among the most important products of the area. Some of the oldest raisin vineyards in the State are found around College City and Woodland. The first raisin grapes produced commercially in this country are said to have been grown on a farm near Woodland. The Muscat and Seedless Sultana varieties are the principal raisin grapes, while the Zinfandel, Alicante Bouschet, and Petit Syrah are probably the leading varieties of wine grapes.

In the selection of soils for the grape, the lighter textured soils of the Yolo and Arbuckle series have been most largely planted, though the vineyards grown on the well-drained parts of the clay loam types have shown as good yields as those upon the sandy loam and loam soils. Southwest of Madison the Esparto loam and Esparto clay loam are well adapted to the growing of grapes and a number of vineyards are found in this section. In the College City and Arbuckle section the Arbuckle loam and Arbuckle gravelly loam are regarded as excellent grape soils. Many new vineyards have been planted during the past few years in the vicinity of Arbuckle, west of Williams, and in the southern part of the area. The most thorough methods of cultivation are practiced in the growing of grapes and other deciduous

fruit. Practically the entire area of grapes is grown without irrigation and cover crops and commercial fertilizers are rarely used.

Many varieties of deciduous fruits are produced in the area. This industry is most extensively developed around Winters, Yolo, Woodland, and Washington. Many thrifty orchards are also found in other sections. In the order of their importance these fruits consist of peaches, apricots, almonds, prunes, plums, pears, cherries, and olives. Citrus fruits and figs are grown in limited quantities. Most of the apricots are grown in the Winters district, and in recent years the dried apricot from this section has been shipped to foreign markets, most of the foreign shipments being to Germany.

A large portion of the fruit produced in the area is packed and shipped as fresh fruit, the remainder being either dried or canned. Peaches, apricots, and prunes are dried in the open air, after which the crop is hauled to the packing house, where it is graded and packed under separate brands. The packing houses at Winters are both cooperative and independent concerns and handle a large portion of the fruit produced in this section. The canneries located at Winters and Yolo get more or less of the fruit produced, and apricots, peaches, plums, and other fruits, including muscat grapes and olives, are canned, and olive oil is manufactured.

The almond orchards around Davisville, Yolo, and Winters at present furnish most of this crop. In general the same soils that are regarded as especially adapted to the grape are used extensively for other deciduous fruits. The fine sandy loam, loam, and clay loam of the Yolo series are the most productive fruit soils in the Winters and Yolo sections and the Sacramento fine sandy loam has been found to be well adapted to the production of pears near Washington.

Throughout the fruit-growing districts the orchards receive intensive cultivation and considerable attention is given to pruning and spraying. With the exception of pear blight, which has been very destructive in recent years, the fruit is comparatively free from serious fungus and insect pests.

The labor employed in the fruit-growing districts is largely Japanese, Chinese, and Hindoo. During the harvest season additional help is secured in the towns and from other sources for the picking and packing of fruit. The wages paid to ordinary day labor frequently exceeds $1.50 per day and a fairly satisfactory supply of farm laborers can usually be secured.

In 1906 the average size of the farms in Yolo County was 349.3 acres and in Colusa County 883.4 acres, the wide difference being probably due to the larger number of small fruit farms of 20 to 40 acres which are found in the southern part of Yolo County.

The development of the Woodland area has been retarded by the lack of adequate facilities for irrigation and to the dry farming of

extensive tracts to grain crops. Recently the demand for small farms ranging in size from 10 to 40 acres or more has increased in this section. Some large tracts have been subdivided into small irrigated farms and many such farms can now be purchased in different parts of the area at prices varying from $60 to $200 an acre.

SOILS.

In relation to topographic position and to origin of the material from which they are derived, the soils of the Woodland area fall into two natural divisions. These may be classed as the intermingled residual and colluvial soils of the lower foothills and as the more extensive alluvial soils of the valley floor.

In earlier geologic times the Sacramento Valley was submerged by the waters of an inland lake or an arm of the sea. Into these waters was washed during Pleistocene time material derived from the rocks of the adjacent mountains and land masses. This was deposited as stratified beds of clays, sands, and gravels, or as beaches composed of gravel mingled with finer material. Upon reelevation and recession of the waters these accumulations, some of which had become quite firmly consolidated, were exposed to weathering and erosion. Great quantities of the material were removed, leaving a greater thickness of the beds along the edges and more elevated slopes of the valley. The lower rounded foothills of the Coast Range occurring along the western margin of the survey are of this material, which here consists principally of ferruginous and calcareous conglomerates rarely exposed, and of partially weathered shales, which are often encountered at shallow depths and are frequently interstratified with fine to coarse sand and silt.

Subsequent weathering of the exposed material has given rise to residual soils. Some of this residual material, through gravity or the action of heavy rains, has slid, rolled, or been washed for short distances and accumulated as colluvial material over the lower slopes. This more or less intermingled residual and colluvial material constitutes the soils of the first division, which are thus seen to be derived mainly from Pleistocene rocks.

The reelevation and erosion of the valley has been followed by deposition over the valley slopes and along the flood plains of the larger streams of more recent alluvial material. This is of varying degrees of fineness and has been transported by flood waters for considerable distances and more or less completely buries the older Pleistocene deposits. Within the Woodland area the alluvial materials are derived mainly from the shales and sandstones of the Coast Range Mountains. In the more recent deposits, found in the vicinity of the larger streams, material derived from crystalline or altered rocks of the more remote mountain ranges enters to a greater extent.

The sediments covering the valley plain were deposited by foothill streams over the slopes or carried eastward to the Yolo and the Colusa basins and commingled with the silts and clays of the Sacramento River to form the deep and uniform soils of the eastern part of the area. The predominance of silt and clay in the materials thus transported has produced soils of a relatively heavy texture, the extensive upland plain being covered principally by loams, clays, and clay adobes, often of extreme fineness of texture and closeness of structure.

The sandy and silty material is confined to comparatively inextensive areas which occur chiefly along the flood plains of the Sacramento River and Cache and Putah creeks.

This group of sediments gives rise to the soils of the second division, viz, recent alluvial soils of the valley plain and river flood plains. Being, usually, of great depth and of uniform texture, they are, when well drained, adapted to a wide range of cultivated and field crops, and in favorable locations the lighter types are important fruit soils.

The soils of the Woodland area have been separated into seven different series, which vary in number of soil types, in extent of distribution, and in importance to agriculture.

The following table gives the names and the actual and relative extent of the several soils:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Sacramento heavy clay	84,672	12.9	Sites clay loam adobe	9,984	1.5
Sites clay adobe	73,152	11.1	Sacramento fine sandy loam	9,920	1.5
Willows clay adobe	45,696	7.0	Esparto clay loam	8,832	1.3
Sites gravelly sandy loam	37,504	5.7	Dunnigan clay	8,576	1.3
Sacramento silt loam	36,480	5.5	Willows clay loam	8,448	1.3
Capay clay	34,560	5.2	Willows clay	6,336	1.0
Capay clay adobe	31,232	4.8	Sacramento silty clay	6,208	.9
Sacramento clay adobe	29,952	4.6	Sacramento sand	5,440	.8
Yolo clay	29,888	4.6	Sacramento fine sand	5,184	.8
Yolo clay loam	27,520	4.2	Riverwash	4,352	.7
Arbuckle gravelly sandy loam	24,000	3.7	Sites loam	3,392	.5
Arbuckle clay loam	21,632	3.3	Esparto loam	3,200	.5
Arbuckle gravelly loam	16,128	2.5	Arbuckle fine sandy loam	3,200	.5
Arbuckle loam	14,912	2.3	Capay clay loam	1,600	.2
Yolo loam	13,568	2.1	Sites silt loam	1,600	.2
Yolo silt loam	13,504	2.1	Willows loam	1,152	.2
Yolo fine sandy loam	11,264	1.7	Sacramento silty clay loam	640	.1
Esparto clay	11,200	1.7			
Yolo silty clay	11,072	1.7	Total	656,000	

DUNNIGAN CLAY.

The Dunnigan clay is known in some sections as "hog-wallow" land. It is a very indefinite type as regards texture and color. The most typical areas consist of about 3 feet of a heavy, yellow to dark gray or black clay, underlain by a bright yellow or brown clay. It possesses a waxy, sticky consistency when wet, and shows a decided tendency to puddle. The surface assumes a bright yellow or grayish-white color on drying, and forms a hard, impenetrable crust.

The occurrence of the Dunnigan clay is limited to a number of long, narrow areas or smaller bodies near the west side of the Yolo and Colusa basins. It occupies depressions or low, flat, poorly drained areas. The surface is generally slightly uneven, owing to the presence of "hog-wallow" depressions. It occupies a position between the Yolo and Colusa basins and the upland, and is subject to overflow during seasons of high water. It has originated from the fine wash from the flood waters of the basins and wash from higher soil bodies. Alkali is always present and in most cases prevents the growing of any crop. The concentration of the salts at the surface is usually sufficient to prevent the proper germination and rooting of seed. Without the aid of underdrainage the areas of this type are, in general, unfitted for the production of cultivated crops and are best suited to permanent pasture.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Dunnigan clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21120	Soil	0.1	0.5	0.6	2.3	1.1	30.8	64.5
21121	Subsoil	.0	.7	.5	8.7	10.9	35.3	43.7

SACRAMENTO SERIES.

The Sacramento series of soils occurs throughout the eastern part of the area and is confined between the western limits of the Yolo and Colusa basins and the Sacramento River. These soils have resulted mainly from the deposition of material transported by the Sacramento River in times of flood. The soils are usually of great depth and vary in texture from the sands and silts adjacent to the river to the clays of fine texture covering the Yolo and Colusa basins.

By far the greater part of the area included in the types of this series occupies the lowlands to the west of the Sacramento River and is subject to yearly overflow. Some extensive tracts are protected from overflow by levees and constitute the greater part of the cultivated area. Where these soils are free from overflows they rank

among the most productive soils of the area. The lighter types are especially adapted to deciduous fruits and various cultivated crops, while the types of heavier texture, when free from alkali, constitute important soils for grain and hay.

SACRAMENTO SAND.

The Sacramento sand consists of 2 feet or more of loose, incoherent sand of light-gray to dark-gray color. The sandy material frequently extends to a depth of 4 to 6 feet and is underlain by material of heavier texture. This soil represents recent wash from the Sacramento River, deposited from rapidly moving water, and is usually associated with breaks in the river levees or places where the flood water leaves the channel. The surface is marked by ridges and mounds and is either barren of vegetation or is covered with a growth of young cottonwood and willow trees.

In its present condition the soil is unsuited for agricultural purposes. With the reclamation of the areas of this type from overflow and the proper leveling of the surface, it could be brought under cultivation and would be adapted to the production of garden truck and other intertilled crops.

The following table gives the results of mechanical analysis of the soil of this type:

Mechanical analysis of Sacramento sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21145	Soil	0.0	3.1	30.5	60.0	2.3	2.2	1.0

SACRAMENTO FINE SAND.

The Sacramento fine sand is a light-brown or buff micaceous fine sand usually extending to the depth of 6 or more feet. The subsoil, however, is often marked by the occurrence of pockets or thin strata of silty, loamy or coarser sandy material. The section is quite variable in texture and is marked by frequent changes in the texture and position of the underlying strata.

Several small areas of this soil type occur near the Sacramento River in the vicinity of Washington. It occupies positions on the higher elevations approaching the river and is mostly included within present reclamation districts. It is chiefly used for the production of alfalfa, hops, and garden crops. Some small tracts are rented to Chinese or Japanese vegetable gardeners, on which truck is produced for the city markets. The soil is easily cultivated and

possesses the natural warmth and retentiveness of moisture required by this class of crops. Its chief value is along the present line of vegetable gardening and for crops requiring intensive culture.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Sacramento fine sand.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21143	Soil	0.1	1.0	2.9	59.1	20.6	14.0	2.9
21144	Subsoil	.1	.4	1.7	78.0	11.4	6.5	1.4

SACRAMENTO FINE SANDY LOAM.

The Sacramento fine sandy loam consists typically of a silty, micaceous fine sandy loam of light-gray to dark-brown color. The soil to a depth of 2 feet is usually of uniform texture; below this the subsoil varies from fine sandy loam to silt loam, often of great depth. The subsoil is marked by the occurrence of thin strata of silt or sand and frequently contains shallow pockets of fine sand. Along the outer edges of the type the soil rests on a substratum of clay.

Areas of this soil type occur extensively along the Sacramento River throughout the survey. In the vicinity of Grimes, where the largest bodies are found, it occurs as broad ridges along Corbiere, Dry, Sycamore, and other sloughs. Owing to its slightly elevated position, it is usually well drained and free from alkali. The surface is sloping or gently undulating, except in a few places near the river north and east of Mormon Basin, where the topography is flat.

The Sacramento fine sandy loam is devoted to the production of Bartlett pears, plums, peaches, and, near Washington, hops. Owing to the extreme depth and the retention of moisture by the soil it produces excellent yields of fruit without irrigation. In other sections potatoes, corn, and alfalfa are produced. In favorable years potatoes yield from 150 to 200 bushels per acre and alfalfa produces from 5 to 8 tons per acre in four cuttings. The English walnut thrives on this soil and is grown to a small extent near Grimes. The soil is chiefly used for wheat and barley in the Grand Island section. The yields of barley vary from 12 to 25 sacks to the acre, with a probable average of 16 sacks. Wheat yields about 12 sacks per acre in average seasons. In addition to the crops mentioned above, the type is adapted to bush fruits, vegetables, sugar beets, and most intertilled crops.

The average results of mechanical analyses of the soil and subsoil are given in the following table:

Mechanical analyses of Sacramento fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
19821, 21146.....	Soil.....	0.1	0.3	0.8	25.9	26.2	36.1	10.9
19822, 21147.....	Subsoil.....	.0	.1	.3	34.4	29.4	27.7	7.7

SACRAMENTO SILT LOAM.

The Sacramento silt loam is a buff to dark-brown smooth, micaceous silt loam of variable depth. The subsoil below a depth of 30 inches usually consists of drab or bluish-black, heavy silt loam, or silty clay. The higher-lying bodies frequently contain thin layers of fine sandy loam or sand in the subsoil. A distinct phase of the type occurs south of Grays Bend. The soil here is made up of 18 inches or more of gray or buff silt loam containing a large quantity of fine mica flakes. It is underlain by fine sandy loam or more commonly by a black, waxy clay similar in texture to the adjacent heavy clay type of soil. This phase represents the more recent formation. In the relatively older type, farther north, the color and texture have undergone considerable modification by cultivation and weathering, producing a soil of close structure and more pronounced tendency to puddle and check on the surface. When the moisture conditions are favorable the soil is easily cultivated, producing a friable seed bed.

The topography varies from flat or nearly level to broad slopes flanking the river or larger sloughs. Extensive bodies of the type occur in the Yolo and Colusa basins throughout the area surveyed. Near Grays Bend it forms the main floor of the basin, though the soil occurs more frequently near the eastern border of the lowlands. As a result of low elevation it is usually poorly drained and is largely subject to overflow. Where the surface has sufficient slope drainage conditions are greatly improved. Alkali is sometimes present, particularly in the upper part of the soil, where it is most damaging to shallow-rooted crops. The better drained parts of the soil are very productive and are cultivated to wheat, barley, beans, potatoes, asparagus, and other vegetables, and to field crops in the vicinity of Washington and south of Grand Island. Wheat and barley are the chief crops produced on the type in other sections. The yields of barley vary from 10 to 20 sacks to the acre, though larger yields are sometimes obtained.

A large part of this soil type is annually overflowed and is only available for pasture during the dry months of the year. Where it is

favorably situated it is adapted to beans, potatoes, beets, and other truck crops, and to forage, hay, grain, and other general farm crops.

Below are given the results of mechanical analyses of samples of the soil and subsoil of this type:

Mechanical analyses of Sacramento silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
19823	Soil	0.1	0.9	0.3	1.8	9.0	71.2	16.8
19824	Subsoil	.0	.5	.4	1.4	7.2	67.5	23.0

SACRAMENTO SILTY CLAY LOAM.

The Sacramento silty clay loam is a dark-gray or dark-brown, micaceous, silty clay loam. The soil has a smooth silty texture to a depth of 2 to 6 feet and is usually underlain by a rather compact clay of dark-brown color. The surface soil is usually free from gravel. Under favorable moisture conditions the soil cultivates readily, forming a loose friable surface, but when plowed too wet it becomes compact and is easily puddled.

This type is of small extent, being confined to three separate bodies along the extreme northern margin of the area. It occurs within the depression of the Lower Colusa Basin, and the surface of the type has the flat nearly level topography of this region. The native vegetation consists of weeds and grasses, the type being treeless in this locality. As a result of the low elevation the overflow from the Sacramento River and the surface drainage of the higher lands to the west collect upon the surface for varying periods in the winter months during seasons of excessive floods. Under ordinary conditions the surface drainage is well established and the soil is capable of fairly early cultivation in the spring.

A part of the Sacramento silty clay loam is devoted to the production of wheat and barley. The low-lying parts are rarely farmed owing to the frequency of floods. Grain crops are often grown for several years upon the same land and moderate yields are secured. With improvement in drainage it will probably be found especially adapted to the production of hay, wheat, barley, sugar beets, and other crops. Both the soil and subsoil to a depth of 6 feet are free from excessive quantities of alkali salts.

SACRAMENTO SILTY CLAY.

The Sacramento silty clay is a gray or bluish-black smooth silty clay of heavy texture. The subsoil below a depth of 3 feet is composed of a dark-gray, compact, impervious clay of considerable depth and of uniform texture. The soil in places has received a thin surface

covering of silty material which gives it a more friable structure. It is generally very sticky when wet, and at such times is unfit for plowing or cultivation. When in proper condition it can usually be plowed without great difficulty, though during recent years the soil has become increasingly difficult to till, owing largely to a change in the physical condition of the soil.

The Sacramento silty clay is confined to the northern part of the area. It forms a large body on the west side of Sycamore Slough and a smaller area near the Sacramento River north of Grimes. The surface topography is flat or has a slight slope in the direction of the local drainage. It is occasionally overflowed by the waters of the Colusa Basin. Small quantities of alkali salts occur, principally in the lower depths of the soil.

The chief crops grown on this type at present are wheat and barley, which produce good yields in favorable seasons. The soil is not usually summer-fallowed for grain, owing to the frequency of floods and damage to early sown crops. During wet years the soil is sometimes disked and planted without plowing. Under present conditions the type is best adapted to grain and hay crops.

SACRAMENTO HEAVY CLAY.

The Sacramento heavy clay is a bluish-black or drab clay usually of great depth. The section to a depth of 6 feet generally shows no abrupt change between the surface soil and the subsoil. The soil possesses a plastic, adhesive character, checking slightly on the surface when dry, but never resembling a true adobe. The upper 30 inches of the soil contains a large quantity of well-decomposed vegetable remains which forms black streaks or aggregations of matter not thoroughly incorporated with the soil particles. Analyses of typical samples of soil from the Colusa Basin show 3.01 per cent of organic matter in the upper 30 inches. Along the western edge of the type and at several places along the Sacramento River the surface has received a shallow deposit of local wash, which slightly influences the texture and cultivation of the soil.

The Sacramento heavy clay occurs throughout the Yolo and Colusa basins. It forms the main floor of the basin region north of Grays Bend, and several small detached bodies on Grand Island. The surface possesses no irregular topographic feature, and is either flat with no perceptible slope or has a slight dip toward the shallow central trough. The occurrence of alkali is chiefly confined to the northern areas of this type. It is usually more concentrated in the subsoil and rarely affects the present cultivation of the soil. Grain crops are occasionally affected by increased amounts occurring near the surface, especially during recent years. The native vegetation consists of cocklebur, bur clover, tules, mint, smartweed, and other

water-loving plants. In the parts containing large amounts of alkali, heath, cressa, and spike weed constitute the principal growth.

In the neighborhood of Grand Island a large area of this soil type has been reclaimed from overflow and cultivated for many years. In this section it is entirely devoted to grain. The soil is rarely summer-fallowed and in the absence of favorable weather for plowing the surface is sometimes disked and planted without plowing. In the unreclaimed parts of the type the physical condition of the soil is unfavorable for the growth of most deep-rooted crops. Where this soil type is protected from overflow and is free from alkali it is adapted to grain, sorghum, Egyptian corn, hay, and other forage crops.

The texture of the soil and subsoil are shown in the following table:

Mechanical analyses of Sacramento heavy clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
19188, 19190.....	Soil.....	0.1	0.7	0.9	3.3	1.4	41.2	52.3
19189, 19191.....	Subsoil.....	.1	.5	.3	1.4	.5	46.6	50.4

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 19188, 1.84 per cent; No. 19189, 1.62 per cent; No. 19191, 0.88 per cent.

SACRAMENTO CLAY ADOBE.

The soil of the Sacramento clay adobe is a gray or grayish-black clay with a depth varying from 24 to 36 inches. The subsoil consists of dark-brown clay which usually grades into light yellowish brown clay near the lower part of the section. The soil is of compact, dense character possessing the adobe structure and forming deep surface cracks during the dry season. It absorbs moisture rapidly and becomes very plastic and adhesive when wet.

This soil type forms two extensive areas along the west side of the Yolo and Colusa basins and several small detached bodies are found near the main type. The surface is flat and usually without marked slope. The natural drainage is usually deficient. Owing to the relatively low topographic position occupied by the areas, they are subject to overflow from the Yolo and Colusa basins. A variable amount of alkali is present in the soil and subsoil, but it is often not sufficient to prohibit the growth of shallow-rooted crops. The native vegetation consists chiefly of a thick growth of alkali weeds and wild grasses.

Small areas of this type are occasionally cultivated to grain crops and produce profitable yields. It is frequently overflowed during the winter months and is chiefly used for pasture. When protected

from floods the soil, where free from alkali, is well adapted to grain and hay crops.

The texture of the soil and subsoil are given in the following table:

Mechanical analyses of Sacramento clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
19117	Soil	0.0	0.4	0.3	4.0	3.0	46.9	46.3
19118	Subsoil	.0	.3	.4	6.1	7.3	48.5	38.3

YOLO SERIES.

The Yolo series of soils is derived from the material transported by the waters of Cache and Putah creeks and minor sloughs. The soil material has originated from a wide variety of rocks occurring in the deeper recesses of the Coast Range Mountains and the lower hills. A very large amount of this material has been deposited by Cache and Putah creeks. With the exception of the Sacramento River, Cache Creek has been the most active agent in the transporting of soil material into the area, the alluvial deposits from this stream extending from Britona for some distance south, where it unites with material of similar character and texture that has been carried by Willow Slough and Putah Creek, forming with these areas the main body of the Yolo series of soils. These soils extend along Putah and Cache creeks to the western limits of the area, as a narrow strip and consist chiefly of the silty and sandy types.

In general they are of great depth and are free from alkali and are among the most productive soils of the area. Six types occur in this series.

YOLO FINE SANDY LOAM.

The Yolo fine sandy loam consists of 15 inches or more of rather light fine sandy loam of a light-brown color, underlain by brown sand or fine sandy loam which frequently contains strata of loam or silt loam. The subsoil is often stratified with coarse sandy streaks and thin beds of silt. East of Davis the soil is underlain at shallow depths by the clay material of the Yolo Basin. The immediate surface is sometimes covered to a depth of a few inches by wind-blown sand, and near the creeks by which the soil is laid down the upper 6 or 8 inches may be similar to the silt loam in texture, the difference in the type being due to the lighter texture of the underlying soil. Along Putah Creek the soil is often of great depth and of uniform texture.

This type occurs in the southern part of the area as numerous small bodies between Cache and Putah creeks, where it extends with some interruptions from Winters to the Yolo Basin. The surface is generally sloping or slightly undulating, and this feature combined with the open texture of the soil favors surface drainage and ready percolation of water downward, so that rain and irrigation water rarely collect in pools on the surface. On the other hand, the soil has strong capillary power, which maintains favorable moisture conditions during the growing season. The areas of the type are largely cleared and under cultivation, except close to streams, where they often remain overgrown with willow, cottonwood, and alder.

The Yolo fine sandy loam has been formed in comparatively recent times by sedimentation from the shifting currents of the larger streams of the plain during periods of floods. West of the town of Winters this type forms the lower bench lands along Putah Creek and is devoted to the production of apricots and peaches. The deep rooting of fruit trees, vines, alfalfa, and grain which is promoted on this soil renders them less sensitive to extremes of drought.

This soil type has been largely dry-farmed to grain with high average yields. Alfalfa, peaches, apricots, almonds, and grapes are grown on different parts of the type. It is believed that prunes yield heavier crops on this type than on the adjacent heavier soils, the principal orchards being west of Woodland and along the south side of Cache Creek at Yolo. Alfalfa produces from 5 to 7 tons an acre with irrigation. Small tracts are rented to Italian gardeners and are kept in cultivation the year round, producing a variety of truck crops. Near Davis and Woodland sugar beets have recently been introduced on this type of soil. The soil is well adapted to the production of deciduous fruits, alfalfa, sugar beets, truck, and a wide variety of general farm crops.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Yolo fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21170, 21172.....	Soil.....	0.2	1.2	2.2	25.2	36.3	23.3	11.6
21171, 21173.....	Subsoil.....	.0	1.1	2.4	21.4	33.3	28.8	12.9

YOLO LOAM.

The surface soil of the Yolo loam consists of a dark-brown loam of light to rather heavy texture. The soil is usually free from gravel. Below a depth of 24 inches the subsoil is generally made up of strata

of silty loam or sandy loam. At greater depths this rests on clay loam or clay, though in a number of places, where old stream beds have existed, gravel occurs beneath the soil at a depth of 4 to 6 feet. The presence of silty material gives a smooth, loamy texture to most of the type. Borings taken at close range show a decided variation in the texture of different parts of the section. In a few places, notably east of Britona and northwest of Merritt, a small percentage of gravel may occur near the surface.

The Yolo loam is well distributed over the southern part of the area. The largest bodies occur north of Yolo, near Woodland and on Putah Creek. Where the type occupies positions on the plain it is usually somewhat elevated above surrounding areas. Along Putah Creek it forms a narrow border which extends from Winters nearly to Davis. The type forms low undulating ridges or more commonly the surface is flat. It is well drained, except in a few places east of Britona where the surface is depressed and drainage water collects during wet weather. The soil here is dark in color and small quantities of alkali occur. With this exception the occurrence of alkali in sufficient amount to affect the growing of crops is confined to one or two small spots south of Woodland.

Owing to the excellent drainage and comparatively open texture of this type, it has proved to be well adapted to fruit, including peaches, almonds, prunes, and grapes. Prunes are said to be benefited by irrigation. The light texture of the surface is favorable to the high degree of cultivation required for these crops. While irrigation has not been in general use, it has been found to be beneficial to the tree and fruit where the lower strata of the soil lack the close texture and compactness necessary for the retention of moisture. It is one of the best general purpose soils in the region and is adapted to a wide range of crops.

The following table gives the average results of mechanical analyses of the soil and subsoil of the Yolo loam:

Mechanical analyses of Yolo loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21176, 21178.....	Soil.....	0.1	0.4	0.9	9.5	27.3	43.3	18.2
21177, 21179.....	Subsoil.....	.0	.4	1.4	14.3	16.5	49.3	18.1

YOLO SILT LOAM.

The Yolo silt loam is somewhat variable in the texture of the surface soil. Typically, it consists of about 3 feet of light to dark brown silt loam of heavy texture, underlain by brown silty clay. In local areas the subsoil shows considerable variation in texture. A phase

occurs east of Yolo along the north side of Cache Creek which possesses strata of fine sand and silt below a depth of 2 feet, and south of the creek the subsoil is frequently of a loose sandy loam texture, underlain at shallow depths by heavier material or by pockets of nearly pure sand. Where the subsoil is sufficiently open and porous, excess moisture is rapidly dispelled and the soil permits early spring plowing. It is generally friable when cultivated, but if plowed when wet it has a tendency to puddle.

In the neighborhood of Yolo this soil type forms a large irregularly shaped body on both sides of Cache Creek. There are a few detached areas farther west and several bodies occur along the old Cache Slough and immediately north of Putah Creek.

The Yolo silt loam consists of the fine sand and silty material deposited by streams. It occurs usually on the slopes approaching the ridges along stream channels. Except in a few small areas where the topography is flat, the surface slope and porous character of the subsoil afford good natural drainage. In the vicinity of streams the tree growth consists of oak, cottonwood, and willow.

The type is well adapted to a wide range of crops under irrigation, though at present considerably less than half its area is irrigated. It is chiefly dry farmed to grain, yielding from 8 to 16 sacks. It is well adapted to the various fruits grown in this section and to alfalfa, sugar beets, garden vegetables, and other cultivated crops.

The texture is shown in the following table, which gives the results of mechanical analyses of the soil and subsoil of the Yolo silt loam:

Mechanical analyses of Yolo silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
20274	Soil	0.0	0.1	0.1	1.2	5.0	69.1	24.4
20275	Subsoil	.0	.0	.0	1.7	9.1	61.3	27.9

YOLO CLAY LOAM.

The Yolo clay loam is a light-brown or chocolate-brown clay loam. At a depth of 3 feet the color assumes a lighter shade and the texture may change to a heavy clay loam or clay. Both the soil and subsoil are somewhat variable in texture. The upper 3 feet of the soil is typically of compact and close structure. Where the type occurs near stream channels the underlying soil is frequently of a light silt loam texture or occasionally contains streaks of sand. In surface appearance and ease of cultivation it closely resembles the silty clay type of this series.

The largest areas of this soil type are located immediately north of Cache Creek, where it forms the most extensive soil of the valley

plain as far north as Britona. A number of less extensive areas occur between Cache and Putah creeks immediately west of the Yolo Basin. The surface is flat or undulating, and along the side slopes of stream courses it possesses a good slope and is well drained. Few areas occur where the natural drainage is not well established and is unfavorable to the growth of deep-rooted crops. In the neighborhood of Yolo, however, the topography is flat, and with the growing of fruit in that section the soil could be greatly improved by opening surface drains and in places by the use of tile drains.

The Yolo clay loam is an important fruit and alfalfa soil. The yields of alfalfa are considerably increased by irrigation, though only a small area is at present irrigated. The chief crops grown at present are barley, wheat, and hay. Barley yields from 12 to 20 sacks to the acre.

Large areas of this type are favorably situated for irrigation, and with the extension of irrigating ditches the soil will be well adapted to such crops as alfalfa, beets, and garden vegetables and the established varieties of fruit. Grapes of the wine and raisin varieties are well adapted to the well-drained parts of the type.

The following table gives the results of mechanical analysis of the soil of this type:

Mechanical analysis of Yolo clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21180.....	Soil.....	0.0	1.9	3.9	16.6	16.6	42.1	19.0

YOLO SILTY CLAY.

The Yolo silty clay consists of 3 to 6 feet of chocolate-brown silty clay, generally underlain by light-brown clay loam or clay to considerable depths. The type has very indefinite boundaries, merging into adjoining soil types. The texture ranges from heavy to light silty clay, the differences being sufficient to affect the ease of handling. The soil is usually of very smooth texture and the surface sufficiently light to insure easy cultivation if worked at the most favorable time.

This soil is of wide distribution in the southern half of the area, the principal bodies occurring along Cache Creek and in the vicinity of Woodland, while a few inextensive areas are found near Putah Creek east of Winters. The surface is uniformly flat or but slightly undulating. It possesses ample slope to give good drainage of surface water.

In its native state this type was covered with a thick growth of valley oak and smaller trees. At present the greater part is cultivated to grain. The average yield of wheat is probably about

18 sacks, with somewhat larger yields of barley. While wheat and barley have been grown continuously on a considerable area for a great many years, it continues to be one of the most productive dry-farmed grain soils in the area. Recently, alfalfa has been grown extensively near Woodland and on Cache Creek in connection with stock-raising and dairying. Where the crop is grown without irrigation, the increase of weeds requires the plowing of the fields after four or five years, when they are seeded to grain for two or more years before replanting to alfalfa. Instead of the usual summer fallow, crops of wheat and barley are followed by one or two years of pasture, after which two grain crops are produced.

Fruit is grown to a small extent, particularly raisin and wine grapes, in the vicinity of Woodland. It is believed that sugar beets could be grown successfully on this soil with irrigation. As this crop requires intensive cultivation, it would be especially beneficial in checking the growth of obnoxious weeds. A rotation of crops can be recommended which would include wheat or barley, sugar beets, and a leguminous crop. Such a rotation would improve the soil and maintain higher yields of the grain crops. In addition to these crops, fruit, beans, sorghum, Egyptian corn, vegetables, and other crops are adapted to this soil type.

The following table gives the results of mechanical analyses of the soil and subsoil:

Mechanical analyses of Yolo silty clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
20276	Soil	0.0	0.1	0.1	3.2	5.0	58.3	33.5
20277	Subsoil	.0	.0	.3	5.0	12.3	53.8	28.5

YOLO CLAY.

The Yolo clay is a brown or chocolate-brown clay generally extending to depths of 6 feet or more. At a depth of 3 feet the subsoil may assume a lighter color and the texture approach a silty clay. The silty phase of the subsoil may be entirely absent, as is frequently the case on the lower levels, the clay extending below 6 feet. In general the texture is that of a light clay compared with other clays of the area. When moist the soil becomes sticky and puddles readily and assumes a compact, hard surface after exposure to the air. It is less easily cultivated than the Yolo silty clay, and requires careful handling for the best results, but when so managed it can be easily brought into a friable condition. It frequently lacks organic matter in the surface, giving it a more compact and tenacious structure. Where this is supplied the physical condition is greatly improved.

The Yolo clay is confined to the southern part of the area. It is present as numerous bodies of irregular shape between Blacks and Putah Creek and is one of the most productive soils of this section. It occurs in the vicinity of Cache, Willow, and Putah creeks, as long and often narrow bodies having a gentle slope away from the streams. Where it is associated with soils of lighter texture it generally occupies a lower topographic position, covering flat areas in the vicinity of streams. In a few low-lying areas the surface is too level to promote good drainage, but the greater part of the type occupies higher elevations and possesses good natural drainage. Near the edge of the Yolo Basin the lower portions of the type are occasionally overflowed. Small quantities of alkali occur in depressed areas where the drainage is deficient.

This soil type is principally used for the production of wheat and barley, being one of the most productive grain soils of the region. The leading crop is Barley, of which an average yield of about 15 sacks to the acre is secured. A rotation of two years of pasture, followed by one or two years in grain, is sometimes practiced on this type. Alfalfa is also grown between periods of grain crops. With irrigation, from 5 to 8 tons an acre are secured in four cuttings. The careful preparation of the soil appears to be the chief factor in securing a successful growth of this crop. The land should be plowed deeply in the fall, followed in the spring by cross-plowing and harrowing and the crop planted about the last of March or in April. Something less than half the area of this type is irrigated at present.

In favorable locations the soil is adapted to tree fruits, grapes, beets, alfalfa, grain, and other field crops.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Yolo clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
20133, 21182.....	Soil.....	0.0	0.1	0.1	0.9	7.6	50.9	40.4
20134, 21183.....	Subsoil.....	.0	.1	.1	.7	10.9	55.4	32.6

ESPARTO SERIES.

The soils of the Esparto series are derived from material transported by minor streams of the foothills of the Coast Range Mountains and are of recent origin. They have originated from the weathering and decomposition of shales, sandstones, and clays of the lower range of hills. They occur as alluvial deposits, often of considerable depth, overlying the older formation of the valley plain, and consist of loam, clay loam, and clay types. The area occupied by these types

has been extended somewhat during recent years by the systematic flooding of the streams over the heavier and less productive clays of the region, producing soils of lighter and more friable texture. They are free from harmful quantities of alkali salts and are very productive.

The Esparto series is confined to the southwest part of the area, occurring in close proximity to the hills between Cache Creek and the town of Winters.

ESPARTO LOAM.

The Esparto loam is a light-brown or yellowish-brown loam or silty loam to a depth of about 24 inches, resting on a subsoil consisting of light-brown loam or clay loam. In a few places the soil shows strata of sandy loam which are usually of shallow depth. This phase is chiefly confined to the part of the type mapped along the north side of Chickahominy Slough, and the lighter soil here rests on clay loam or clay subsoil below 3 feet.

The Esparto loam occurs as several inextensive areas south of Madison. These bodies are associated with Cottonwood and Chickahominy sloughs. The main parts of the type occupy moderate elevations, making the surface topography slightly inclined and giving the soil good drainage. Both the soil and subsoil are of sufficiently close texture to give the type good moisture-holding properties. It lacks the tendency to bake on the surface shown by the heavier soils of the region and is more easily cultivated.

The Esparto loam is the chief fruit soil in the locality. It is recognized as an excellent grape soil and several thrifty vineyards of wine grapes occur southwest of Madison. Farther south, in the neighborhood of Ely, apricots, almonds, plums, and olives are grown. Several small areas have been sown to alfalfa. This crop produces good yields with irrigation, four crops being cut during the season. Figs are grown to a small extent. The trees attain great size and are very productive. The soil occupies the higher locations which are believed to be less subject to frosts than the lower elevations and are favorably situated for fruit. Other crops to which it is adapted are alfalfa, sugar beets, and the cultivated crops of the region.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Esparto loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21122	Soil	0.2	1.5	3.1	18.9	21.4	32.6	22.2
21123	Subsoil	.0	.9	1.9	13.0	19.7	37.4	26.6

ESPARTO CLAY LOAM.

The soil of the Esparto clay loam is a yellowish or yellowish-brown clay loam with a depth of 3 feet or more. The subsoil is a silty clay or clay loam, usually slightly heavier than the soil and lighter in color. At greater depths it passes into a compact clay similar to the heavier soils of the region. A phase of the soil occurs just west of Esparto and along Cottonwood Slough which approaches a silty clay in texture. The soil has a friable structure, and the character of the subsoil makes it retentive of moisture.

The Esparto clay loam forms a number of very irregular bodies between Madison and Winters. It usually marks the position of present or former streams and occurs as narrow or expansive ridges slightly elevated above the general level. As a result of this topographic feature the surface usually possesses ample slope to insure adequate drainage and a very favorable exposure for fruit.

This type has been one of the most productive grain soils of the section. It is generally summer-fallowed and has been continuously cultivated for many years with less decline in the yields of crops than has been experienced on the near-by soils of heavier texture. Barley produces between 10 and 20 sacks to the acre in average years, depending on cultivation and previous treatment of the soil. Alfalfa is grown to a slight extent with and without irrigation. As most of the type is capable of irrigation the use of water is becoming more general. With irrigation the yield of the crop is about doubled in seasons of average rainfall, producing from 6 to 8 tons to the acre. In connection with dairying the growing of alfalfa can be made very profitable, furnishing, besides hay, fresh pasturage from eight to ten months of the year. The crop is used in this section very profitably as green feed for hogs and poultry.

Several orchards, including apricots, peaches, figs, and almonds, are located on this soil and in ordinary years fruit has been a profitable crop. While the region appears to be slightly more liable to frosts than in the protected valleys, it probably possesses a greater freedom from low temperatures than points farther out in the main valley. Grapes have been one of the most profitable fruit crops.

The soil is adapted to fruit, alfalfa, beans, beets, grain, and general farm crops suited to the region.

The texture is shown by the results of mechanical analyses given in the table following:

Mechanical analyses of Esparto clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21126	Soil	0.0	1.1	3.1	12.7	11.4	40.8	30.3
21127	Subsoil	.0	1.6	4.1	15.9	12.9	35.5	30.0

ESPARTO CLAY.

To a depth of 2 or 3 feet the soil of the Esparto clay is a yellowish-brown or dark-brown clay. It is underlain at this depth by clay or clay loam of a light-brown color. At a depth of about 4 feet the texture frequently becomes lighter, grading into a silty clay or silt loam in the lower part of the 6-foot section. Near streams or sloughs which overflow, the immediate surface is usually more silty than in the broader areas of the type. Such areas are also more easily cultivated and lack the tendency to form the compact crust and to assume the lumpy condition of the heavier phase. Unless plowed and cultivated at the proper time, the soil breaks up into hard clods which it is difficult to reduce by harrowing, but it is distinctly of a lighter texture than other clays of the region and has a correspondingly wider range of moisture condition within which it can be cultivated and planted.

The Esparto clay is found south of Madison as an extensive unbroken area on the broad slopes approaching the hills in this section. A few small bodies occur farther south and to the east of the main area. Its topography varies from flat on the lower levels to easy slopes along the streams and at the base of the hills. Drainage is generally good and the heavy character of the soil makes it retentive of moisture and productive during dry seasons.

The soil has been extensively dry-farmed to grain. It is generally summer-fallowed for grain crops. At present barley is grown almost exclusively, yielding on the average about 12 sacks per acre. Within recent years irrigation has been applied to alfalfa and the acreage of this crop is gradually increasing. The natural slope and drainage make it capable of easy and inexpensive irrigation. A large part of this soil is within easy reach of irrigation ditches though a comparatively limited area is planted to crops which need to be grown with irrigation.

The Esparto clay is adapted to general farm crops suited to the region and especially to alfalfa in connection with dairy farming. With careful cultivation and preparation, sugar beets could probably be grown successfully with irrigation. A crop requiring clean cultivation is needed in a rotation of crops for this soil, and this want would be supplied by the sugar beet, sorghum, or Egyptian corn, all of which are adapted to the soil. However, the cultivation of these crops would require a more intensive system of farming than is practicable under present conditions and management of the land. Fruit, including peaches, apricots, almonds, figs, and grapes, is grown to a small extent and in favorable locations good yields are obtained.

The following table gives the results of mechanical analyses of the soil and subsoil:

Mechanical analyses of Esparto clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21128	Soil	0.0	0.3	0.9	5.9	7.6	43.4	41.6
21129	Subsoil	.2	.4	1.2	6.1	6.7	42.6	43.4

CAPAY SERIES.

The Capay series of soils occurs in the southwestern part of the area and extends from the upper part of Hungry Hollow across the southern end of the area to the Yolo Basin. Two important soil types occur in this series consisting of a clay and clay adobe with a few inextensive areas classed as clay loam.

These soils consist of the finer grades of sediment resulting from the weathering of complex rocks of the Coast Range Mountains and deposited over the valley plain, where temporary lakes or pools have been formed during periods of heavy rainfall and floods. They are derived mainly from wash from adjacent areas of soils of the Yolo or other series occupying higher elevations. The soils are characterized by dark gray color, fineness of texture, and are of a heavy, plastic character. Owing to the flatness of the surface, drainage is often deficient and alkali occurs in excessive quantities in some places, greatly interfering with the growing of crops. The utilization of the areas most affected with alkali would require artificial drainage and, under existing conditions, this is hardly practicable.

CAPAY CLAY LOAM.

The Capay clay loam consists of a gray to brown clay loam frequently extending to 6 feet in depth. The soil is sometimes influenced by local wash from the smaller streams of the plain, and where it occurs as low ridges may approach a loam in texture. Below a depth of 30 inches the subsoil is usually heavy, wherever the type occurs on the lower elevations, consisting of a reddish-brown clay. A small percentage of fine gravel sometimes occurs in the upper part of the soil. The surface lacks the compact character common to the heavier soils of the region and forms a friable, mellow seed bed when cultivated.

Several small areas of the Capay clay loam are found north of Cache Creek in Hungry Hollow. They occur principally along small intermittent streams as recent alluvial deposits. They are well drained and free from alkali. In addition to grain crops, almonds and grapes are grown to a small extent in these areas.

The following table gives the results of mechanical analysis of the soil of the Capay clay loam:

Mechanical analysis of Capay clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21184.....	Soil.....	0.2	1.8	2.3	10.9	16.9	44.5	23.2

CAPAY CLAY.

The Capay clay consists of about 3 feet of heavy tenacious clay of a gray or grayish-brown color, sometimes tinged with red. Very frequently, and particularly in the Hungry Hollow section, this is overlain by 3 to 5 inches of a rather light loam. At about 36 inches the soil grades into a dense reddish-brown or yellowish-brown clay. Both soil and subsoil are usually of very heavy texture and while the type does not closely resemble the adobe, it becomes plastic when wet and requires careful handling to get the best results from cultivation. If plowed when too wet it is very difficult to work.

The Capay clay is confined to the southwestern part of the area. It forms an extensive soil type in the lower part of Hungry Hollow and is found well distributed over the southern part of the area west of the Yolo Basin. The surface is broken by occasional sloughs and creeks which have cut deep channels or flow on slightly elevated ridges. The surface is usually flat and drainage imperfect. Under these conditions alkali may occur in both soil and subsoil, and is occasionally sufficient to preclude the growth of any but the most shallow-rooted crops.

The soil is devoted to the production of grain and grain hay. Barley yields from 6 to 14 sacks, with an average of about 9 sacks. A large amount of hay is produced. The higher lying areas which occur mainly in Hungry Hollow are more productive and are generally less subject to alkali. In the more favorable locations the soil is well adapted to grain, hay, and forage crops, and to alfalfa under irrigation.

CAPAY CLAY ADOBE.

The Capay clay adobe consists of about 3 feet of a dark-brown or grayish-brown clay, underlain by a clay subsoil which is variable in texture and color, though it is prevailingly yellowish brown or reddish-brown. As a rule the subsoil is quite heavy and very compact. At a depth of about 6 feet this sometimes rests on a lighter stratum containing a large amount of coarse sand. Above this the lighter texture of the subsoil and the occurrence of a perceptible amount of sand is usually associated with a light yellow color. The soil becomes very

hard and compact in dry weather and is sticky when wet. It has the adobe characteristic of forming deep surface cracks and checks.

The clay adobe type is extensively developed south of Cache Creek and west of the Yolo Basin. It extends with some interruptions from a few miles north of Swingle to the upper part of Hungry Hollow. The topography is invariably flat and the surface often possesses but little slope. As this type is confined to the lower levels of the plain, the drainage is often imperfect. The occurrence of alkali very frequently reduces the yields of crops and in some cases has resulted in turning the land over to permanent pasture. The native vegetation consists of pasture grasses, wild oats, and various alkali weeds. The greater part of the area is cultivated to grain, producing nominal yields. Where the drainage is not defective, the productiveness of the soil could be increased by using a rotation of crops which would include a legume. As this soil is best adapted to the production of hay and grain crops the introduction of a systematic rotation of crops, or at least of a winter-growing green manure crop, should receive attention in any attempt to increase the production of grain crops.

The following table gives the results of mechanical analyses of the soil and subsoil:

Mechanical analyses of Capay clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21186	Soil	0.0	0.2	0.5	2.1	4.1	48.7	44.4
21187	Subsoil	.0	.6	.5	2.3	6.5	51.3	38.7

ARBUCKLE SERIES.

The Arbuckle series forms an extensive group of soils between Dunnigan and Williams, extending from the western foothills to the Colusa Basin. The northern boundary of these soils is roughly marked by old Cortina Creek. In texture they vary from loose sandy types containing a large amount of gravel, occurring mainly west of the Southern Pacific Railroad, to loams and clay loams of the valley plain. The outlying portion of the plain is traversed by many long narrow ridges of the gravelly types.

The Arbuckle series of soils has originated from the rapid erosion of the outer range of hills west and south of Arbuckle, which are composed largely of coarse conglomerates and shales. The degradation products, consisting mainly of gravelly sands and clay, have been carried outward by rapidly flowing streams, from which they have been deposited over the floor of the valley in this region, obliterating former surface features, and except in a few places in the eastern part completely covering the floor of the valley. The soils are of compara-

tively recent origin. They overlie the clay formation of the valley plain at variable depths, the older formation being occasionally exposed on the lower elevations. The areas formed in this manner have been considerably elevated above the rest of the plain. The soils are marked by good depth and ease of cultivation. The open and porous texture of the lighter types, combined with a well-established natural surface drainage, make them especially adapted to fruit crops under irrigation.

ARBUCKLE FINE SANDY LOAM.

The Arbuckle fine sandy loam is decidedly variable in texture. The surface material consists usually of a fine sandy loam occasionally approaching in texture a coarse sandy loam underlain by sandy loam or strata of a silty or sandy nature. The average of the section to a depth of 6 feet is usually fine sandy loam. Gravel occurs at variable depths. A small percentage is frequently present near the surface and at 4 feet in depth the soil may rest on thick strata of sand and gravel. The color of the soil is usually brown, assuming a gray tint when dry. The subsoil is typically of a yellowish-brown color.

A single large body of this type occurs south of Williams, while a number of small bodies are found scattered over the area as far south as Dunnigan. It represents the coarser material deposited by streams traversing the plain, and its manner of deposition accounts for the variability in texture.

The larger bodies are well drained and comparatively level. With irrigation these can be used to advantage for garden crops and fruit.

The following table gives the results of mechanical analyses of the soil and subsoil:

Mechanical analyses of Arbuckle fine sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21152	Soil	0.4	5.8	10.6	33.3	20.5	17.1	12.1
21153	Subsoil	.0	4.1	8.5	32.7	25.4	18.4	11.0

ARBUCKLE GRAVELLY SANDY LOAM.

The Arbuckle gravelly sandy loam, to a depth of 18 to 36 inches, is a grayish or yellowish-brown gravelly sandy loam. The soil contains a high percentage of small rounded gravel. The subsoil is typically a reddish-brown gravelly clay loam. Near the base of the steeper slopes the lighter textured material of the soil extends to a depth of 4 feet or more. The typical subsoil occasionally grades into a compact gravelly clay or gravelly sand. When wet the color of

the soil is a reddish brown, assuming a pink tint on exposure and drying. The light texture of the surface and compact lower strata promote a boggy condition of the soil during wet weather and early in the spring, and the surface has a tendency to become hard and compact when the water has been removed through evaporation.

The largest area of this soil occurs southwest of Arbuckle as an unbroken body extending to the base of the foothills. It occurs farther out on the plain as narrow ridges along old stream beds. A few detached bodies occur south and east of Williams.

The topography of the Arbuckle gravelly sandy loam varies from broad uniform slopes or slight undulations in the main body of the type to flat areas along the streams. The surface is sometimes dissected by deep channels of foothill streams and sloughs. It is subject to considerable surface wash on the steeper slopes. The native tree growth consists of blue oak, digger pine, and chaparral, which are confined to the low benches along the larger streams.

This soil type has been exclusively farmed to grain until recently, when attempts have been made to establish grape vineyards and fruit in a few sections. Some success has followed the planting of these crops in connection with thorough cultivation of the soil. Any extensive cultivation to fruit, alfalfa, and other crops would probably be unsuccessful without facilities for irrigation. The parts of the type where the soil is deepest are believed to be well adapted to the fruits of the region and to alfalfa, vegetables, and other farm crops with irrigation.

The following table gives the average results of mechanical analyses of the soil and the result of a single analysis of the subsoil of this type:

Mechanical analyses of Arbuckle gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21110, 21112.....	Soil.....	9.2	12.1	9.1	22.9	16.1	22.4	7.7
21113.....	Subsoil.....	3.3	6.5	6.2	21.0	18.3	27.8	16.7

ARBUCKLE LOAM.

The upper stratum of the Arbuckle loam consists typically of 24 to 30 inches of light-brown or grayish-brown loam of friable structure and containing a considerable percentage of sand. The subsoil, which is variable in texture, generally consists of brown sandy loam or loam. This grades into the clay loam or clay of the adjacent soils on the lower elevations. A small percentage of gravel is usually present in the soil and subsoil. Narrow areas of gravelly material occur within the type, which are too small in extent to be indicated on the

map. The continuous cultivation of this soil to a uniform depth has developed a compact plow sole near the surface. This compacted layer occurs at a depth of 4 or 5 inches and the soil is usually plowed and cultivated to this depth only. Areas which have been plowed deeper are free from this condition.

The Arbuckle loam forms one of the most important soil types in the northern part of the area. The surface is usually sloping or slightly uneven and possesses good natural drainage. The largest bodies of the type occur north of Dunnigan and southwest of Williams. Smaller areas are scattered throughout this section. The soil usually occurs as alluvial deposits near present or former streams. In general it forms extensive areas occupying the more elevated parts of the valley plain. It is free from alkali.

While grain has been grown to the exclusion of other crops, the texture of the soil, which promotes ease of cultivation, the uniform topography, and the good drainage conditions adapt it to a wide range of crops. Wheat yields from 6 to 15 sacks per acre, and barley slightly more. Summer fallowing is always practiced for these crops.

North of Dunnigan and in other localities almonds and raisin grapes have been profitable crops. It is one of the best grape soils of the region and is well adapted to deciduous fruits. The yields of grain could be increased by the adoption of a systematic rotation of crops, including a legume.

The use of a winter-growing leguminous crop which could be plowed into the soil would itself tend to restore and maintain the productiveness of the soil. The areas occupied by this type are favorably situated for irrigation and the natural topography will facilitate the application of water. The extension of irrigation to this region will make possible the more intensive cultivation of this soil. It is well adapted to such crops as alfalfa, fruit, Kafir and Egyptian corn, sorghum, beets, and other general farm crops. The areas mapped include some of the highest priced lands in the northern part of the survey. Fully 90 per cent of the area of this type is included in large holdings, though the soil is well adapted to the smaller farm and more intensive farming methods.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Arbuckle loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21114	Soil	0.0	0.7	1.2	6.2	23.1	45.6	23.1
21115	Subsoil	.3	.8	1.8	12.9	20.5	43.5	19.9

ARBUCKLE GRAVELLY LOAM.

The Arbuckle gravelly loam shows considerable variation in texture and in the proportion of gravel present in the soil. It consists typically of about 2 to 3 feet of grayish-brown loam of light texture, underlain by reddish-brown loam or clay loam. A considerable quantity of small waterworn gravel is present in the soil and subsoil. The subsoil is occasionally of compact structure. A phase of this type which contains a large amount of gravel and is less productive than the rest of the type occurs near the foothills southwest of Arbuckle.

The largest areas of this soil are found in the vicinity of Arbuckle and College City and southeast of Williams. Numerous small areas occur in other parts of this region. It occupies slopes bordering streams or broad undulating areas which are slightly raised above the general level, and is well drained. The character of the subsoil is favorable to the percolation of surface water to the deeper strata of the soil. The type owes its origin to the coarser material transported by the streams traversing the plain.

Practically all of this soil type is dry-farmed to grain, the yields varying from 7 to 12 sacks. It is always summer-fallowed for grain crops. The most profitable crop has been the raisin grape, the oldest vineyards of which are found near College City. The fruit is of large size and makes an excellent dried product, and the vines yield good crops in seasons of average rainfall. The early success with this crop on the Arbuckle gravelly loam led to more extensive planting of the raisin grape, and several young vineyards have recently been started near Arbuckle. Frequent cultivation is essential to the success of fruit trees and vines, owing to the loose texture of the soil.

On the less gravelly phases alfalfa has been grown near Arbuckle and north of Dunnigan. The more extensive production of this crop, as well as some of the intertilled crops, will probably be developed with irrigation. The type is best suited to fruit. It is also adapted to general farm crops with irrigation.

ARBUCKLE CLAY LOAM.

The Arbuckle clay loam consists of brown or grayish-brown clay loam to a depth of 24 to 36 inches. At a depth of 3 feet the soil usually becomes lighter in color, or yellowish brown and in the more elevated areas the subsoil is usually a compact clay loam or clay. Near the larger streams, which occasionally overflow, the surface is often of a loamy character to a depth of 4 to 6 inches. A small proportion of gravel is usually present in the upper part of the soil.

The Arbuckle clay loam is extensively developed in the northern part of the area. The larger bodies are often broken by ridges of lighter soils and the outlying portions grade into the adjoining types of lower elevation with indefinite boundaries. The largest areas occur

between Arbuckle and Williams. North of Dunnigan the type forms numerous bodies of irregular shape. The topography varies from flat to the gentle slopes terminating in the more elevated parts of the plain. The surface is without marked topographic features. The drainage is good, except on the lower parts of the type, where the surface slope is deficient. Near the edge of the Colusa Basin the ground water remains at a high level during the rainy season. In most cases the low-lying areas could be improved by opening ditches to the natural drainage channels, which would prevent the accumulation of surface water.

The Arbuckle clay loam has resulted from the deposition of the finer materials carried by the foothill streams, modified by the later wash from more elevated surrounding soil bodies. Harmful quantities of alkali occur only where the drainage is deficient. The area affected is of relatively small extent and occurs principally at the west side of the Colusa Basin as a number of small patches which are occasionally overflowed.

This soil type is devoted chiefly to the growing of wheat and barley, and ranks among the most productive grain soils in the region. Vineyards of wine and raisin grapes are found in a few sections. The areas which are well drained are adapted to the hardy fruits of the region, and, with irrigation, to general farm crops, alfalfa, and dairy farming.

The following table gives the results of mechanical analyses of the soil and subsoil:

Mechanical analyses of Arbuckle clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21118	Soil	1.6	3.4	2.9	9.2	11.3	45.9	25.8
21119	Subsoil	2.6	5.7	4.5	17.3	22.2	26.6	20.7

WILLOWS SERIES.

The soils of the Willows series consist of stream sediments, usually of reddish or yellowish-brown to dark-brown color, deposited along the courses of minor creeks or in the waters of temporary lakes, and underlain by brown to light-brown compact and relatively impervious subsoils. These are derived from the weathering and decomposition of shaly sandstones and calcareous shales occurring in the Coast Range Mountains and lower foothills. In this series four types consisting of loam, clay loam, clay, and clay adobe were mapped.

In the extreme northern part of the area the material is most typical in color and texture. In other parts of the plain the color and texture of the soils have been modified by recent wash from

adjacent soil types. The largest bodies of the clay and clay adobe occur on the lower elevations of the valley floor west of the Colusa Basin. The soils become lighter in texture nearer the foothills to the west and occupy undulating ridges along the streams or the intervening slopes between the streams and the foothills.

WILLOWS LOAM.

The Willows loam consists of a light yellowish brown loam varying in depth from 30 to 36 inches, resting on a subsoil typically a light-brown loam. The soil is sometimes of lighter texture than the underlying material and may grade into either a sandy loam or clay loam below a depth of 4 or 5 feet. Both soil and subsoil are free from gravel. In general, the texture of the type is that of a light, friable loam, easily cultivated, porous, and favorable to the growth of deep-rooting plants.

This soil type is chiefly confined to a few small bodies west of Williams. It is found occupying broad sloping ridges or as narrow strips on the higher elevations, in which case the areas are often too small to be indicated on the map. The soil is well adapted to deciduous fruit, particularly raisin, table, and wine grapes, alfalfa, sugar beets, sorghum, Egyptian corn, and other crops.

The following table gives the results of mechanical analyses of the soil and subsoil:

Mechanical analyses of Willows loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21154	Soil	1.3	4.2	4.5	16.5	20.4	34.4	18.2
21155	Subsoil	1.2	3.5	4.7	15.8	16.9	38.6	19.4

WILLOWS CLAY LOAM.

The Willows clay loam is a light-brown or yellow clay loam with a depth of about 3 feet, underlain by brown or yellowish-brown loam or clay loam. It is free from gravel and is of smooth, silty texture. The subsoil is frequently compact, though at a depth of 4 feet it may become lighter in color and texture. The surface is friable if properly cultivated, but forms clods if worked when either too wet or too dry.

The Willows clay loam is of small extent and is confined to the northern part of the area. The bodies most typical in color and texture occur directly west of Williams near the edge of the area. The type occurs as low ridges along stream courses and usually has good surface slope, which affords excellent drainage.

This soil type has been chiefly dry-farmed to grain. Recently a number of grape vineyards of the raisin varieties have been set out and where the vines have reached a bearing age they have been very

productive. The soil is believed to be well adapted to fruit, especially wine, table, and raisin grapes. With irrigation it is also adapted to alfalfa, bush fruits, and general farm crops.

The following table gives the average results of mechanical analyses of the soil and subsoil:

Mechanical analyses of Willows clay loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21156, 21160.....	Soil.....	0.0	0.4	0.9	10.9	21.3	41.4	25.3
21157, 21161.....	Subsoil.....	.0	.4	.8	7.1	14.2	44.6	32.7

WILLOWS CLAY.

The Willows clay consists of about 3 feet of yellowish-brown or drab clay, underlain by a mottled clay varying in color from yellow to dark brown or black. The soil has a compact tenacious structure and checks upon the surface. When it has been subject to wash, it is often of a light loamy texture to a depth of several inches, but such areas are of limited extent. The impervious character of the soil prevents the downward movement of water into the subsoil and frequently produces a water-logged condition during wet weather. The phase of the type occurring as a few small bodies south of Williams has better drainage than the rest of the type and is more productive.

Deficient drainage and the presence of excessive quantities of alkali are characteristics of the larger bodies. The soil type occurs principally in the low depressed areas of the plain and receives the overflow and seepage water from higher elevations, which collects and slowly drains away or evaporates. The existing vegetation consists of alkali weeds and grass. Except for the phase mentioned above the soil is never cultivated, but is devoted to permanent pasture. The reclamation of this soil would require expensive tile draining.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Willows clay.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21166.....	Soil.....	0.1	0.5	1.0	4.0	5.9	41.7	46.7
21167.....	Subsoil.....	1.4	2.8	2.6	7.6	2.5	33.3	49.8

WILLOWS CLAY ADOBE.

The Willows clay adobe to a depth of 3 feet is a dark-brown clay of compact close structure. The subsoil varies from a light-brown to yellow clay. The lighter color is usually reached at 3 to 4 feet, and

occasionally the texture is lighter below this depth. South of College City areas of this type occur which are of darker color than the more typical bodies in the more northern part of the area. The soil possesses the adobe tendency to form deep surface cracks, and checks, with the baking of the surface during dry weather, into small irregular blocks. It sometimes assumes a light-yellow color, owing to surface wash from near-by streams. The usual structure of the upper part of the soil when dry is dense and refractory. The physical character of the soil undergoes a radical change upon the absorption of moisture, as it assumes a plastic adhesive condition when excessively wet and in this state resists plowing and cultivation. With proper cultivation the soil retains a considerable amount of moisture during the dry season and fails to develop the extreme adobe structure noticeable in the dry soil under natural conditions.

The Willows clay adobe is the most extensive soil type of the valley plain north of Cache Creek. It is usually found on the lower elevations of the plain and frequently underlies adjacent soil types of more recent formation. As a rule the boundaries are somewhat indistinct. It forms a number of large irregularly shaped bodies between Williams and Yolo and several small areas west of Williams. The surface is often flat or depressed, and in such places the drainage is deficient. The general topography is slightly undulating or, more frequently, nearly flat. Alkali in dangerous quantities is quite often present in the soil and subsoil. This is particularly true north of College City. From this point south it is usually relatively free from injurious quantities of alkali salts. The subsoil frequently contains a considerable percentage of lime and gypsum, the latter appearing as small masses of crystals. The vegetation consists of a scattered growth of cottonwoods or oaks near the streams and of alkali weeds and wild grasses.

This soil type has been exclusively dry-farmed to grain. The yields vary from 6 to 14 sacks of barley with a probable average of about 9 sacks. Summer fallowing is universally practiced. The topography is favorable for irrigation, and when this is available the areas which are high and well drained will be adapted to additional crops, including alfalfa and other hay and forage crops.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Willows clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21164, 20297.....	Soil.....	0.1	1.2	0.8	3.9	4.7	33.7	55.7
21165, 20298.....	Subsoil.....	.2	1.1	.8	2.2	1.5	37.2	56.9

SITES SERIES.

The Sites series of soils is confined to the slopes and narrow valleys of the outer range of hills found in the western part of the area. The soils consist in part of material containing a large admixture of sand and gravel, the lighter class of material usually occurring to a depth of 18 to 24 inches and resting on coarse gravelly clay or the partially altered clays and shale. These soils have resulted from the weathering and erosion of coarse conglomerates and shales and occur as residual and colluvial material covering the hills and valley slopes, or, to a small extent, as reworked deposits of greater depth extending across narrow valleys. They vary widely in depth, being relatively shallow on the crests of hills and of much greater depth on the lower slopes.

The most extensive soils belonging in this series are the clay adobe and clay loam adobe types, which have been derived from the shale and calcareous clays in place and occur as residual soils occupying the larger part of the hill region.

SITES SILT LOAM.

The Sites silt loam to a depth of 24 inches is a yellow or reddish-brown silt loam of smooth texture usually containing a slight proportion of small waterworn gravel. The subsoil is variable and consists of a dark-red clay loam, loam, or sandy loam. The soil possesses a light, friable structure when cultivated, but has a tendency to form a compact surface crust after drying and exposure.

The Sites silt loam is found as a number of inextensive bodies west of Woodland. It occurs as broad slopes near the base of the hills, south of Cache Creek. It is principally used for the production of barley and wheat. With proper cultivation it is probable that grapes, almonds, and apricots would prove adapted to this soil.

The following table gives the results of mechanical analyses of the soil, subsoil, and lower subsoil of this type:

Mechanical analyses of Sites silt loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21138.....	Soil.....	0.5	3.1	3.2	6.0	8.6	60.5	18.1
21139.....	Subsoil.....	.6	2.3	2.4	5.4	8.0	42.3	38.9
21140.....	Lower subsoil...	1.2	5.5	7.0	14.8	8.8	29.4	33.2

SITES GRAVELLY SANDY LOAM.

The Sites gravelly sandy loam, to a depth of 14 to 30 inches, is a rather heavy sandy loam of light-yellow to reddish-brown color, containing a variable proportion of small to large waterworn gravel.

The subsoil is a reddish-brown or red gravelly loam or heavy sandy loam, which frequently grades into a coarse sandy clay at a depth of 4 feet. In certain areas the soil rests on the partially weathered clayey conglomerate or shale which is compact and impenetrable to the roots of cultivated crops.

The largest bodies of this type occur in the hills in the western part of the area, between Cache Creek and a point west of Arbuckle. Many small areas are found on the knolls and low hills northwest of Davisville, where the type is usually of greater depth and is more productive than in the larger areas. It has been derived from the coarser grades of material resulting from the wash or assorting action of water. The surface is usually rolling or undulating and has good drainage. The lower lying bodies near streams support a growth of digger pine and chaparral.

The Sites gravelly sandy loam is principally devoted to pasture and to the production of grain. Almonds, apricots, and grapes have been grown in a few places on the deeper phases of the soil by intensive cultivation. The yields of crops are generally less than on the lighter soils of the plains. In general this soil type is not suited to the production of fruit. It is not capable of irrigation and is best adapted to the production of grain and hay crops and to pasture.

The texture of the fine earth of this type is shown by the results of mechanical analyses given in the following table:

Mechanical analyses of Sites gravelly sandy loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
19819, 20295, 21130.	Soil.....	4.1	8.8	6.7	18.1	18.6	31.8	12.0
19820, 20296, 21131.	Subsoil.....	1.8	5.1	5.4	17.0	18.3	28.6	23.6

SITES LOAM.

The Sites loam consists of 14 to 24 inches of reddish-brown loam of light texture containing typically a considerable amount of fine sand. The subsoil consists of gravelly loam or sandy loam of dark red color and occasionally of heavy clay loam or clay. Northwest of Dunnigan and in Bird and Oak Creek valleys the type is of slightly heavier texture than in other parts of the area and the clay subsoil predominates.

The soil is inclined to bake on exposure, but with proper cultivation both soil and subsoil are capable of retaining a good store of moisture during the dry season, and the areas of this type have a somewhat wider range of crop adaptation than the other soils associated with them. The principal bodies of the type are found

west of Woodland and southwest of Madison. Separate bodies occur northwest of Dunnigan and in the valley west of Blacks. The type has a sloping or undulating surface and good drainage. It has been formed mainly as colluvial material washed from the higher slopes of the hills. It is largely devoted to grain or used as pasture. Under intensive cultivation it is probable that grapes, almonds, and apricots could be successfully grown on this type of soil.

The following table gives the average results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Sites loam.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
19817, 21136.....	Soil.....	2.6	5.1	3.9	12.3	23.9	38.3	13.9
19818, 21137.....	Subsoil.....	1.9	4.8	3.2	12.2	16.8	36.9	24.2

SITES CLAY LOAM ADOBE.

The Sites clay loam adobe is a grayish-brown to dark-red clay loam, with a depth of 18 to 30 inches, underlain by a compact red gravelly clay loam or by white marl. The soil frequently contains a small quantity of small rounded gravel. It has a typical adobe structure and can be cultivated effectively only when the moisture conditions are favorable.

This soil type forms a continuous body, covering the low ridges of hills southwest of Williams. The topography is rough or gently undulating. The higher parts near the steeper slopes of the foothills support a thick growth of chamisal, manzanita, ceanothus, and scrub oak, while the lower portions are usually treeless and covered with a light growth of native grasses. The soil is dry farmed to grain and produces nominal yields. In other parts it is uncultivated and devoted to permanent pasture.

The following table gives the results of mechanical analyses of the soil and subsoil of the Sites clay loam adobe:

Mechanical analyses of Sites clay loam adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
20118.....	Soil.....	0.0	1.1	0.7	6.1	14.0	46.0	32.1
20119.....	Subsoil.....	.3	1.1	1.1	7.4	14.8	48.6	26.3

The following samples contained more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 20118, 5.51 per cent; No. 20119, 8.92 per cent.

SITES CLAY ADOBE.

The soil of the Sites clay adobe consists of a reddish-brown or gray clay extending to a depth of 18 to 36 inches. The subsoil consists of a compact red clay or of white or greenish calcareous clay or clay loam. The subsoil frequently contains a considerable amount of small rounded gravel, which is usually absent in the upper part of the section. Small areas of gravel are sometimes found capping the higher ridges in the main body of the type. The soil is of a sticky and adhesive character when saturated and forms numerous deep surface cracks and checks during the dry season.

The Sites clay adobe is an extensive soil type west of Blacks and Dunnigan. The surface is rolling or hilly and is dissected by numerous narrow valleys. It is usually not too steep to prevent the use of farm machinery. The vegetation consists of an occasional clump of scrub oak and manzanita and on the higher slopes of chaparral and oak. The lower hills are usually treeless. The crops grown on this type consist of wheat and barley, with a much larger acreage of barley. The yields range from 6 to 12 sacks per acre. To a considerable extent the type is used for pasture and only occasionally summer fallowed and sowed to grain crops. It is chiefly adapted to grain and hay crops and grazing.

The following table gives the results of mechanical analyses of the soil and subsoil of the Sites clay adobe:

Mechanical analyses of Sites clay adobe.

Number.	Description.	Fine gravel.	Coarse sand.	Medium sand.	Fine sand.	Very fine sand.	Silt.	Clay.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
21141	Soil	0.0	0.8	1.8	5.3	5.9	37.2	49.0
21142	Subsoil	.1	.8	1.6	4.9	3.2	38.5	50.8

RIVERWASH.

The areas mapped as Riverwash include the miscellaneous deposits of sand and gravel found along creek beds or extending over inextensive flood plains. Such areas occur chiefly along Cache Creek, west of Yolo, at the lower end of Putah Creek, and west of Williams. In the latter place the type consists of coarse sand, with a small admixture of fine gravel, and has a depth of 18 to 30 inches. The remainder of the type is, in general, too rough or broken to be cultivated. The more extensive areas are subject to overflow during periods of flood and but a few small areas have been cultivated. With a better control of the creeks during flood times, certain parts of the type could be reclaimed.

ALKALI.

A considerable part of the area lying east of the Southern Pacific Railway is deficient in drainage and throughout this region varying quantities of alkali salts occur in the soils. By far the greater part of the alkali lands is found in the northern half of the area, extending across the northern boundary from a point about 2 miles west of Williams to the Sacramento River. This section includes the lower parts of the valley plain known as the "goose lands" and a considerable area in the Lower Colusa Basin. Farther south alkali is found along the west side of the Yolo Basin, in a number of small bodies near the Sacramento River, and in a large tract lying between Madison and Plainfield in the southwest part of the area. The soils of the uplands are in general free from serious amounts of alkali, except for occasional small spots which are usually associated with poor drainage and are too small in extent to be shown in the map.

On the alkali map which accompanies this report is shown the location of the alkali lands and the average percentage of the salts occurring in the soil to a depth of 6 feet. The lands are grouped according to the amount of the total alkali salts into five grades, representing the areas containing less than 200 parts per 100,000, 200 to 400 parts, 400 to 600 parts, 600 to 1,000 parts, and 1,000 to 3,000 parts.

The extent of lands of the several grades is shown in the following table:

Alkali.	Acres.	Per cent.
Less than 200 parts per 100,000	494,976	75.4
From 200 to 400 parts per 100,000	119,168	18.2
From 400 to 600 parts per 100,000	33,664	5.2
From 600 to 1,000 parts per 100,000	7,232	1.1
From 1,000 to 3,000 parts per 100,000	960	.1
Total	656,000	.....

In mapping the alkali lands the growth of certain alkali-resistant vegetation was found to follow very closely the soils which contained sufficient alkali to interfere with the growing of cultivated crops. The most common plants associated with these soil conditions are salt grass (*Distichlis spicata*), alkali heath (*Frankenia grandifolia*), and cressa (*Cressa critica truxillensis*). The occurrence of gum weed (*Grindelia camporum*) and spike weed (*Centromadia pungens*) was usually confined to areas containing comparatively small amounts of alkali in the surface soil. While various other characteristic plants occur, those enumerated are the most common and furnish a ready means of detecting the presence of alkali in the soil.

As to the effect of the alkali upon the growth of ordinary cultivated crops, no general statement can be made which will apply to all parts of the area. Lands containing less than 200 parts per 100,000 rarely showed any unfavorable effects of alkali upon crop growth. Where the distribution of the salt was uniform, the presence of between 200 and 400 parts usually retarded the growth of the more sensitive plants, including wheat and barley, and the grain fields usually showed frequent bare and unproductive spots. Upon lands containing from 400 to 600 parts sugar beets, barley, and other crops were seriously affected, and above 600 parts most cultivated crops refused to grow and the land was of value only for the light pasturage produced.

The question of the distribution of the alkali through the 6-foot section of the soil, or the depth at which the largest amounts occur, is important in considering conditions existing in the alkali lands of the Woodland area. Where the maximum concentration occurs at a depth of 2 feet or more, the upper part of the soil, which represents the feeding areas of shallow-rooted crops, may be comparatively free from harmful amounts of alkali and thus permit the growing of certain shallow-rooted crops upon lands showing a high average salt content for the 6 feet. This explains the success which has followed the planting of grain crops upon some of the alkali lands, particularly in the case of the Willows clay adobe, occurring in the "Goose lands." In this immediate section the average amount of salts to the depth of 6 feet frequently exceeds 600 parts per 100,000, while less than 250 parts is contained in the first 12 inches of the soil.

In the Lower Colusa Basin southwest of Grimes the alkali is more uniformly distributed and the maximum for the first 6 feet rarely exceeds 350 parts per 100,000. In other parts of the Yolo and Colusa basins the conditions were found to be quite variable, though, in general, where the total amount exceeds 600 parts per 100,000 the greatest concentration occurs in the subsoil. In the Capay clay and Capay clay adobe, occurring southeast of Madison and in the Hungry Hollow section just north of Cache Creek the alkali is generally distributed quite uniformly to a depth of 5 feet or more and only in comparatively few cases do the largest accumulations occur at the surface.

In general it can be said that the alkali is confined to the soil types having the texture of clay, heavy clay, and clay adobe. These soils, named in the order of their area beginning with the most extensive, are: Sacramento heavy clay, Willows clay adobe, Capay clay, Capay clay adobe, Sacramento clay adobe, Dunnigan clay, Willows clay, and Sacramento silty clay.

The alkali in the soils of the Woodland area probably owes its origin mainly to the sedimentary rocks, including sandstones and

alkali-bearing shales, from which the material forming the floor of the valley was derived. Local accumulations have resulted from the fine sediments carried in by the foothill streams and deposited in the lower parts of the valley and from the evaporation of drainage waters which collect in the natural depressions of the plain. Such accumulations are usually confined to the upper strata of the soil, and are more or less common along the west side of the Yolo and Colusa basins. The composition of the well water in different parts of the alkali districts indicates that alkali is found in the deep strata of the soil.

The alkali salts consist principally of the sulphates, chlorides, and bicarbonates of sodium. Sodium carbonate or "black alkali" is not present in serious quantities, except in a few small areas. It occurs locally along the west side of the Sacramento River, between Sycamore and Washington, and in the Dunnigan clay type of soil, where it imparts a dark-brown or black color to surface water and produces a puddled or bare appearance of the soil.

In the following table is given the composition of the alkali in a number of typical samples of soil and crusts from different parts of the area, as determined by analyses made in the laboratory of the Bureau of Soils:

Analyses of alkali in soils and crusts.

[Parts per 100,000 dry soil.]

Constituent.	No. 20558. 5 m. E. of Davis, crust.	No. 20387. 5 m. E. of Davis, crust.	No. 20297. 5 m. E. of Williams, soil 0 to 36 in.	No. 20298. 5 m. E. of Williams, subsoil 36 to 72 in.	No. 20299. 5 m. SE. of Woodland, soil 0 to 72 in.	No. 20300. 4 m. E. of Woodland, soil 0 to 72 in.	No. 17. 4 m. NW. of Grimes, soil 0 to 12 in.
Calcium (Ca)	1,680	1,390	76	277	9	4	.....
Magnesium (Mg)	4,330	3,220	12	52	.....	.....	.....
Sodium (Na)	300	3,100	210	668	355	240	69
Potassium (K)	.....	300	.....	.....	.....	.....	33
Sulphate (SO_4)	21,320	20,460	521	2,119	318	194	.....
Chloride (Cl)	250	1,640	34	59	176	36	43
Bicarbonate (HCO_3)	70	300	126	84	224	255	55
Carbonate (CO_3)	.....	.....	.....	.....	18	41	.....
Total parts per 100,000	27,950	30,410	979	3,259	1,100	770	200
Percentage on basis of dry soil	28.0	30.4	0.98	3.26	1.10	0.77	0.20

In samples 20558 and 20387, which are crusts, the predominating salts are sodium and magnesium sulphates, with the corresponding chlorides also present in important amounts. This salt mixture is a bad one for common crop plants, but the analyses show calcium sulphate or gypsum to be an important constituent also, which would be expected greatly to lessen the bad effects the mixture would otherwise have.

Samples 20297, 20298, 20299, and 20300 contain mixtures of soluble salts, in which sodium sulphate is the predominating salt, sodium chloride also being prominent. In 20297 and 20298 gypsum is also present, which lessens the harmfulness of the mixture, but in 20299 and 20300 the soil contains lime carbonate, with the result that small amounts of the very corrosive black alkali are apt to be present unless the drainage and tilth are both exceptionally good.

In No. 17 the harmful constituents are the chlorides of sodium and potassium. The proportion of potassium is unusually high, and under good drainage conditions this soil should rapidly assume satisfactory chemical condition.

The permanent reclamation of the alkali lands of the area would require a complete system of drainage accompanied by irrigation.[a] This method has been successfully used in other sections of the State in the reclamation of alkali lands. On the other hand, the excessive use of water in irrigation might tend to increase the height of the underground water, which at present is found at a depth of 12 feet or more below the surface, except in the lower parts of the plain and the lowlands, and cause the deeper accumulations of alkali to be carried upward in the soil. Owing to the present low value of the lands in which injurious amounts of alkali occur, the heavy impervious texture of the soils, and the necessity of providing underdrainage, the reclamation of any extensive areas would probably not be economical at present.

IRRIGATION AND DRAINAGE.

The supply of water for irrigation purposes is derived mainly from Cache Creek and the Sacramento River. Clear Lake, situated in the interior of the Coast Range Mountains, is the chief source of the water taken from Cache Creek.

As early as 1856 the Moore ditch was constructed to divert the waters of Cache Creek for irrigation purposes. The Capay and Winters Canal, which supplies water to the section south of Capay and on the north side of Putah Creek, and the Adams ditch, extending from Capay to the town of Yolo, were of later construction. In 1903 these separate ditches were formed into the system operated by the Yolo County Consolidated Water Company, and the canals and laterals have been extended, increasing the area irrigated. It is estimated that about 7,000 acres now receive water from the Cache Creek system.

The extension of the canals of the old Central Irrigation Canal system by a private enterprise contemplates the irrigation of the valley

[a] Bul. No. 42 Bureau of Soils, U. S. Dept. of Agr. See also Buls. 34, 35, 43, and 44 of the same office.

lands in Colusa County. In a few instances attempts have been made to utilize the underground water by pumping. A number of pumping plants have been in use along the Sacramento River, at Cache Creek near Yolo, at Arbuckle, and other sections, in irrigating alfalfa and fruit, though no extensive development of this source of supply has been undertaken.

Of the area irrigated at present, between 85 and 95 per cent is in alfalfa. With the use of water the yields of this crop are usually doubled and one or more additional cuttings are made during the season. Irrigation is not usually practiced with fruit. It is thought that the kinds of deciduous fruit grown could be irrigated to advantage on the lighter soils, particularly in seasons of low rainfall, and the practice is increasing in some sections. Any extensive production of tilled crops, such as corn, beans, tomatoes, and other vegetables, sugar beets, potatoes, and garden truck, on the dry soils of the plain will depend on the use of irrigation to supplement the early spring rains. The same holds true for the successful production of alfalfa and other forage and field crops on most of the upland soils. For a further discussion of this subject the reader is referred to a recent publication of the Office of Experiment Stations of the United States Department of Agriculture, entitled "Irrigation in the Sacramento Valley, California," by Samuel Fortier.

The drainage of the area west of the Yolo and Colusa basins is fairly efficient, by reason of the natural slope of the plain. The surplus surface waters during the rainy months readily find their way into the natural sloughs and drains and are carried to the lowlands farther east. Near the edge of the basins and in other parts of the plain low, flat areas occur, which could be greatly benefited by artificial drainage. This is particularly the case over a considerable area southeast of Madison and east of Williams. The present drainage conditions favor the further accumulation of alkali salts in these sections. In most cases the water which drains from higher levels could be prevented from collecting in the depressions by cutting surface drains in the direction of the natural outlet. In general the soils devoted to fruit culture are well drained. Where the surface is flat and nearly level, as along the north side of Cache Creek near Yolo and south of Grimes, artificial surface drainage, or even underground tile drainage, would be very beneficial.

The reclamation of the Yolo and Colusa basins is involved in the more extensive problem of the control of the flood waters of the Sacramento River and tributary rivers and streams. The natural trough formed by these basins is subject to yearly inundation by the floods of the Sacramento River, Cache, Putah, and other creeks and sloughs flowing eastward from the Coast Range Mountains. Between Grimes and the southern end of the area several large

tracts are protected from overflow by levees. In the neighborhood of Grand Island about 72,000 acres are included in Reclamation District No. 108. For the construction of levees in this district and for pumping and other purposes the expenditure in some cases has exceeded $40 an acre. The cost of maintaining such a system of levees and the frequency of floods causing injury to levees and crops have made the private reclamation systems very expensive to the landowners. It is scarcely likely that permanent improvement can be made until the draining of the Sacramento Valley is projected upon a much larger scale than is possible at present by the individual landowners.

SUMMARY.

The Woodland area, California, is situated on the west side of the Sacramento Valley and includes the greater part of Yolo and the southern half of Colusa counties. It comprises an area of rich agricultural lands lying between the foothills of the Coast Range Mountains and the Sacramento River. The entire area surveyed is capable of agricultural development.

The topography of the country is marked by three main physiographic divisions, including the lower foothills in the western part of the area, the broad, flat valley plain, and a strip of lowlands occurring in the Yolo and Colusa basins along the eastern side of the area. The drainage of the upland plain which forms the most extensive and productive portion of the survey is afforded by numerous streams traversing the valley from west to east and having their outlets along the west side of the basins. During the rainy months, the Yolo and Colusa basins are subject to overflow.

The climate is characterized by a wet and a dry season and a long comparatively hot summer with clear days and nights. Hot "northers" are occasionally experienced during the spring and summer. The climate as a whole is unusually favorable for the production of crops. The average precipitation at Davis, in the southern part of the area, is 16.55 inches.

The agriculture of the area consists in the production of dry-farmed crops, including principally wheat and barley, with a comparatively small amount of alfalfa, sugar beets, and other field crops, and the rather extensive production of the deciduous fruits adapted to the region.

Stock raising has been an important branch of farming since the early days. There are a few dairy farms in the area, and this industry gives promise of considerable growth. The growing of alfalfa upon the irrigated lands of the area is being gradually extended, and this crop is very profitable in connection with stock raising or dairying

and the production of baled hay. Sugar beets have been introduced recently and give good promise of success on some of the lighter soils of the valley.

The leading fruits are peaches, apricots, plums, prunes, almonds, pears, and grapes, including wine, raisin, and table grapes. The more highly developed fruit-growing districts at the present time are found in the southern and southwestern parts of the area. Large areas of soils occur which are well adapted to a variety of fruits. Next to grain farming, fruit growing is the leading industry of the region.

Several well-equipped packing houses and canneries are located in the area.

For many years the agricultural development of the region has been slow, but recently there has been considerable activity in the purchasing of small irrigated farms, and upon such areas more intensive methods of cultivation are being introduced.

The present value of the dry-farmed lands ranges from $5 to $100 an acre, while irrigated farms of 10 to 40 acres or more can be bought for $60 to $200 an acre, depending on the location and soil. In general, the soils of the upland plain and higher river bottom lands are free from alkali.

The chief source of improvement in the agriculture of the area lies in the extension of irrigation over the dry plains and the substitution of more intensive farming methods for dry farming.

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ALKALI MAP

CALIFORNIA
WOODLAND SHEET

LEGEND

Less than 200 parts per 100000 — A

From 200 to 400 parts per 100000 — B

From 400 to 600 parts per 100000 — C

From 600 to 1000 parts per 100000 — D

From 1000 to 3000 parts per 100000 — E

Alkali Surveyed by
C. W. Mann, J. F. Warner, H. L. Westover
and James E. Ferguson
1909

BASE MAP IN PART FROM
U.S. GEOLOGICAL SURVEY SHEET

Scale 1 mile

Contour interval 20 feet.
Contours where shown are taken from U.S.G.S. sheets

Soil Operations
Bureau of Soils
1909

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SOIL MAP

CALIFORNIA
WOODLAND SHEET

SOIL PROFILE
(6 feet deep)

- Dunnigan clay — C
- Sacramento sand — S
- Sacramento fine sand — Sf, Sil
- Sacramento fine sandy loam — Fsl
- Sacramento silt loam — Sil, Sc
- Sacramento silty clay loam — Sicl
- Sacramento silty clay — Sc
- Sacramento heavy clay — C
- Sacramento clay adobe — Cad
- Yolo fine sandy loam — Fsl, Sl
- Yolo loam — L, Sl
- Yolo silt loam — Sil, Sc
- Yolo clay loam — Cl
- Yolo silty clay — Sc
- Yolo clay — C
- Esparto loam — L
- Esparto clay loam — Cl
- Esparto clay — C
- Capay clay loam — Cl
- Capay clay — C
- Capay clay adobe — Cad
- Arbuckle gravelly sandy loam — Sl, Cl
- Arbuckle gravelly loam — L, Cl
- Arbuckle fine sandy loam — Sl
- Arbuckle loam — L
- Arbuckle clay loam — Cl
- Willows loam — Hl
- Willows clay loam — Cl
- Willows clay — C
- Willows clay adobe — Cad
- Sites gravelly sandy loam — Sl, Hsl, Sc
- Sites loam — L, Sl
- Sites silt loam — Sil, Sl
- Sites clay loam adobe — Cladd
- Sites clay adobe — Cad, C

LEGEND

- C Clay
- S Sand
- Sl Sandy loams
- Sil Silt loam
- Fsl Fine sandy loam
- Sc Sandy clay
- Sicl Silty clay loam
- Cad Clay adobe
- L Loam
- Gl Clay loam
- Hl Heavy loam
- Cladd Clay loam adobe
- Hsl Heavy sandy loam

LEGEND

- Dunnigan clay — Dc
- Capay clay loam — Zcl
- Sacramento sand — Ss
- Capay clay — Zc
- Sacramento fine sand — Ssl
- Capay clay adobe — Zca
- Sacramento fine sandy loam — Sfsl
- Arbuckle gravelly sandy loam — Agsl
- Sacramento silt loam — Sasl
- Arbuckle gravelly loam — Agl
- Sacramento silty clay loam — Sscl
- Arbuckle fine sandy loam — Asl
- Sacramento silty clay — Ssc
- Arbuckle loam — Al
- Sacramento heavy clay — Sc
- Arbuckle clay loam — Acl
- Sacramento clay adobe — Sca
- Willows loam — Wl
- Yolo fine sandy loam — Yfsl
- Willows clay loam — Wcl
- Yolo loam — Yl
- Willows clay adobe — Wla
- Yolo silt loam — Ysil
- Sites gravelly sandy loam — Ggl
- Yolo clay loam — Ycl
- Sites loam — Gl
- Yolo silty clay — Ysc
- Sites silt loam — Gsil
- Yolo clay — Yc
- Sites clay loam adobe — Gla
- Esparto loam — El
- Sites clay adobe — Gca
- Esparto clay loam — Ecl
- Riverwash — Rw
- Esparto clay — Ec
- Swampy areas
- Gravelly areas

Soils Surveyed by
C. W. Mann, J. F. Warner, H. L. Westover
and James E. Ferguson.
1909

BASE MAP IN PART FROM
U.S. GEOLOGICAL SURVEY SHEET

Scale 1/62500
1 0 1 2 3 4 Miles
1 0 1 2 3 4 Kilometers
Contour interval 50 feet.
Contours where shown are taken from U.S.G.S. sheets

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